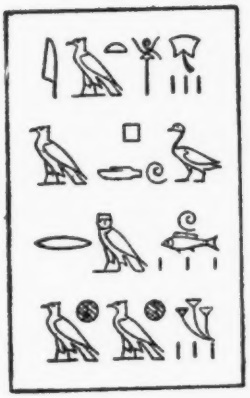
THE JOURNAL OF WILDLIFE MANAGEMENT



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THE JOURNAL OF WILDLIFE MANAGEMENT

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PRESENT STATUS OF MIGRATORY WATERFOWL IN HAWAII[1]

Joseph S. Medeiros

Board of Agriculture and Forestry, Territory of Hawaii, Kahului, Maui

Migratory ducks and shorebirds have regularly made their way each winter, apparently for centuries, to the Hawaiian Archipelago. They have not always come in the same numbers; there were years when very few migrants spent the winter in Hawaii, and there were other years when waterfowl wintered here in great numbers.

In 1890 the first ornithological expedition set foot on the Hawaiian Islands, then called the Sandwich Islands. Members of the early expeditions were interested primarily in the indigenous Hawaiian birds; observations on migratory waterfowl were recorded only incidentally, the emphasis being on the records of stray visitants rather than on the abundance of the primary migrants, the pintail (*Anas acuta*) and the shoveler (*Spatula clypeata*). Wilson and Evans (1890–99) listed shovelers as being "common." In his notes Palmer (Rothschild, 1893–1900) said that "ducks and other birds were very numerous but very wild." Henshaw (1902) listed buffleheads (*Bucephala albeola*) as the "commonest of continental ducks." That must have been an unusual migration because this species was never common during the six years of the present study. Munro (1944) listed the pintail and shoveler as "regular migrants," and the rest of the waterfowl as "stray visitants."

Recently, Schwartz and Schwartz (1949) reported that several thousand pintails wintered in Hawaii in 1943. During their survey they also found two canvasbacks (*Aythya valisineria*) and one bufflehead.

It is important to management to determine whether or not Hawaii is a terminal point in a regular migration or whether Territorial waterfowl are casual or accidental visitors. If our ducks are regular migrants, then one improperly handled hunting season could drastically reduce the migrant population so that Hawaii would have few, if any, migratory ducks remaining. On the other hand, if it is found that the ducks in Hawaii are stragglers from the Pacific Coast, their total elimination in one year would have no effect upon the following year's supply. It was to establish the existence or absence of a regular waterfowl migration that a banding program in the Hawaiian Islands was begun in 1949.

PROCEDURE

In conjunction with the January waterfowl inventory made throughout the United States, regular counts were also conducted throughout the Territory. On Maui, total counts were made more frequently, and sexes of the pintails and the shovelers were recorded.

During the first year of the study, trapping and banding were carried out at Kanaha Pond on Maui and the Mokapu peninsula on Oahu. During the next two years, all of the waterfowl work was concentrated on the island of Maui.

[1] A contribution from Pittman-Robertson Wildlife Research Project 5-R under Director Vernon E. Brock. This project was suggested and first supervised by J. Donald Smith, now with the U.S. Fish and Wildlife Service; it was supervised later by John R. Woodworth, Chief, Bureau of Game, Board of Agriculture and Forestry. Sincere appreciation is due William H. Elder, John E. Chattin, Seth H. Low, and Charles and Elizabeth Schwartz for their help with the manuscript, and to the many members of the Board of Agriculture and Forestry, members of the Pacific Flyway Committee, and others who contributed so generously of their time and interest.

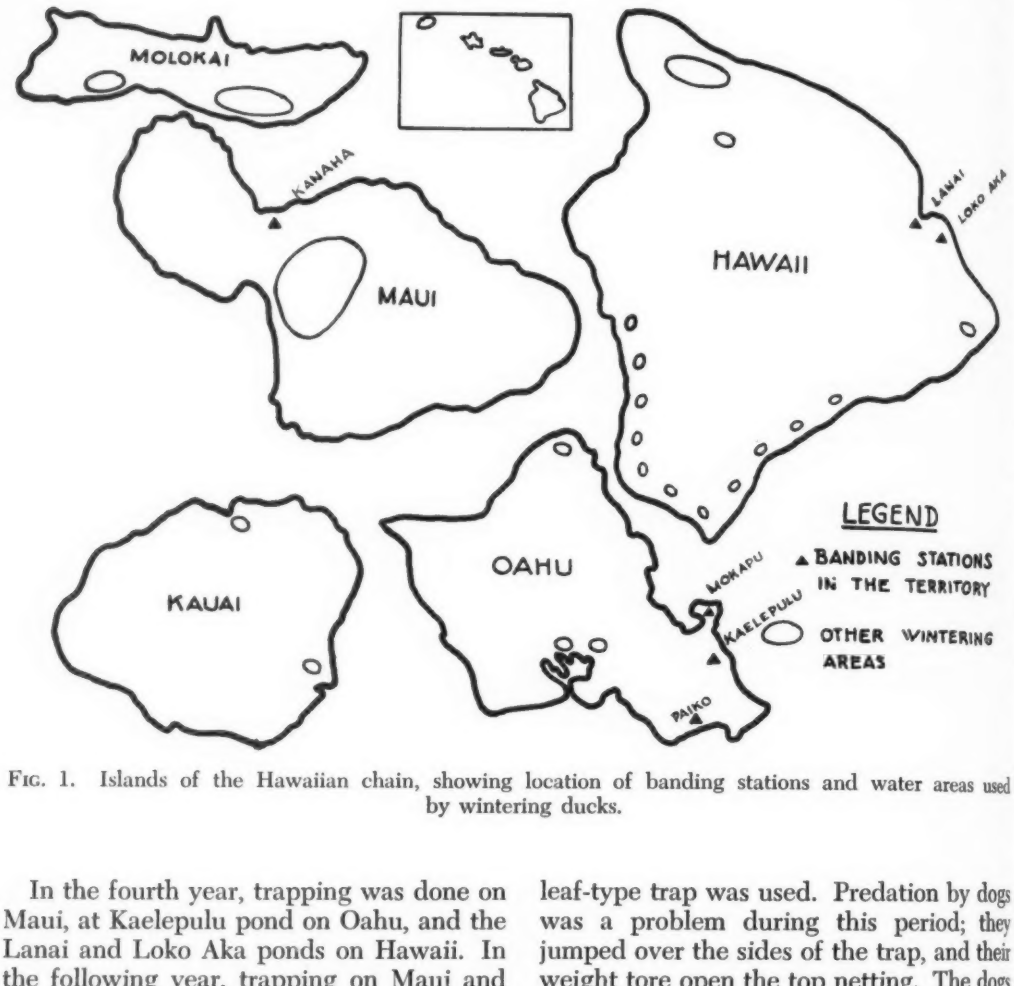

FIG. 1. Islands of the Hawaiian chain, showing location of banding stations and water areas used by wintering ducks.

In the fourth year, trapping was done on Maui, at Kaelepulu pond on Oahu, and the Lanai and Loko Aka ponds on Hawaii. In the following year, trapping on Maui and the Loko Aka pond on Hawaii was again undertaken with the site on Oahu changed from Kaelepulu to Paiko pond. In the sixth year, as very few pintails wintered on the island of Hawaii, trapping was restricted to Kanaha Pond on Maui and Paiko pond on Oahu. The location of these banding stations is shown in Fig. 1.

Only pintails were trapped in significant numbers. The only shovelers and American widgeons (*Mareca americana*) banded were those picked out of the Kaelepulu pond during an outbreak of botulism in December 1953. One green-winged teal (*Anas carolinensis*) was trapped in the winter of 1949–50.

During the first three years, a clover-leaf-type trap was used. Predation by dogs was a problem during this period; they jumped over the sides of the trap, and their weight tore open the top netting. The dogs killed the ducks but did not eat them. It appears that waterfowl are able to avoid cats, dogs, or mongooses (*Herpestes auropunctatus*), if these are encountered in the open, because no signs of kills other than in the trap were found during the period of the study.

During the fourth and subsequent years a new trap designed by J. Donald Smith was used; it had a manually operated drop door which was sprung whenever a sufficient number of ducks were seen in the trap. This trap eliminates injury to birds that are penned for a long period, and also eliminates the danger of loss to dogs and mongooses.

I found that by setting off fireworks or firing a shotgun the ducks could be induced

TABLE 1.—NUMBERS OF WATERFOWL WINTERING IN THE HAWAIIAN ISLANDS AS SHOWN BY THE JANUARY INVENTORY

	1950	1951	1952	1953	1954	1955
Oahu	539	1200	5200	3812	723	1684
Molokai	50	80	148	342	116	286
Maui	902	1262	2223	4578	2455	2520
Hawaii	293	125	363	1730	533	4[1]
Totals	1,784	2,667	7,934	10,462	3,827	4,494

[1] Includes 3 pintails on Kauai.

to leave certain outlying reservoirs and concentrate at the trapping site. For this reason, I shall consider trapping sites as one per island.

STATUS WITHIN THE TERRITORY

Numbers and distribution.—Table 1 shows the annual abundance of wintering waterfowl in the Territory of Hawaii. Pintails far outnumber shovelers throughout the islands. The island of Maui is the only island of the group where shovelers may be more abundant than pintails. Although the island of Hawaii is larger than the other islands combined, it does not attract as many waterfowl as Oahu and Maui because it has no large fresh-water areas.

In 1954 the Kaelepulu pond on Oahu, an area that previously had as many as 3,000 ducks, was drained, thus causing the drop in numbers of ducks on that island. Drainage of the Oahu ponds has continued at an accelerated rate during the past 20 years.

Arrival and departure dates.—The dates of first arrivals of pintails varied from August 20 to September 18; shovelers followed pintails by about a week. The arrival and departure dates of the other migrants could not be determined because of their small numbers. Kozlik (*in litt.*) states that in California pintails usually appear during the first week in August and shovelers during September.

Over the six years of observation, departure dates for pintails varied from the latter half of January to March 7. Timing of

TABLE 2.—PEAK COUNT PER TWO-WEEK PERIOD ON SAMPLE AREA OF MAUI

Period	Pintails					Shovelers				
	1950–1951	1951–1952	1952–1953	1953–1954	1954–1955	1950–1951	1951–1952	1952–1953	1953–1954	1954–1955
Aug. 16–31	7	—	50	—	—	—	—	—	—	—
Sept. 1–15	9	281	1010	24	57	13	14	40	140	110
Sept. 16–30	19	308	400	18	161	54	418	150	625	505
Oct. 1–15	82	†	775	178	120	270	†	220	857	480
Oct. 16–31	†	†	800	536	645	†	†	1200	1206	1725
Nov. 1–15	†	1575	†	898	900	†	485	†	1015	1195
Nov. 16–30	160	†	535	623	905	340	†	660	1450	1400
Dec. 1–15	500	†	617	875	885	500	†	395	1020	1015
Dec. 16–31	215	1275	†	821	480	432	450	†	755	1035
Jan. 1–15	†	1630	1200	798	†	†	593	1850	962	†
Jan. 16–31	†	†	350	691	†	†	†	1500	730	†
Feb. 1–15	†	†	228	435	†	†	†	1500	990	†
Feb. 16–29	76	†	†	740	†	732	†	†	890	†
Mar. 1–15	2	1470	†	1095	665	528	1075	†	1245	1030
Mar. 16–31	0	25	175	107	150	458	1200	1825	1292	1670
Apr. 1–15	0	0	50	6	0	681	†	1600	1330	1380
Apr. 16–30	0	0	0	0	0	713	800	1550	1486	2275
May 1–15	2	0	12	0	3	133	150	150	941	752
May 16–31	4	0	48	0	3	1	0	2	39	0

† = No counts made during this period.

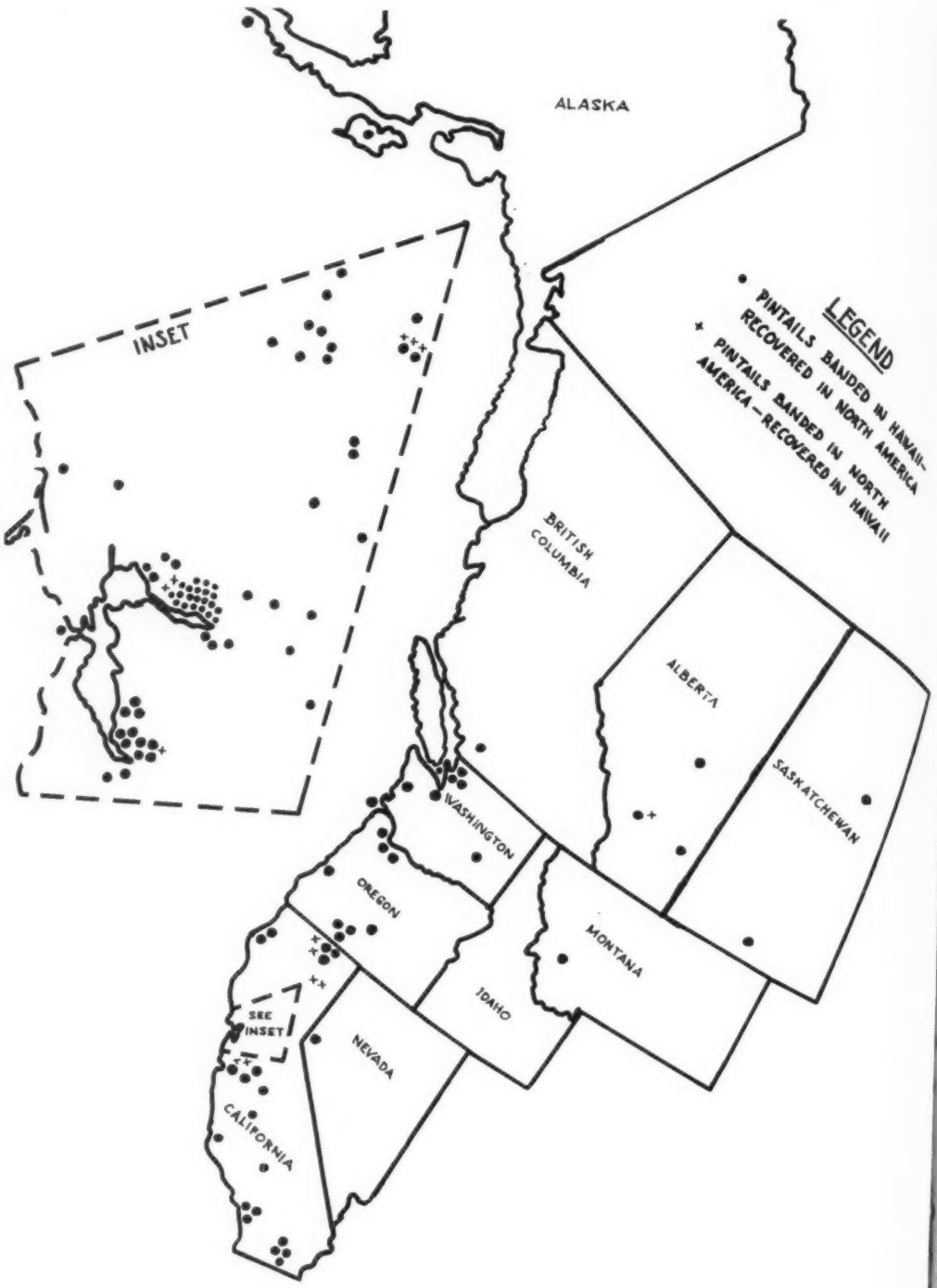

FIG. 2. Points of recovery of pintails banded in Hawaii and reported from the mainland, and of banding stations on the mainland from which ducks have come to Hawaii.

shoveler departures has been much more uniform, always occurring within the short period from April 21 to May 9. Kozlik states (*in litt.*) that in California pintails begin leaving the first of March, while the majority of shovelers there leave in April.

Peaks of migration.—The population build-up of both the principal migrants is generally a gradual one (Table 2). In the two-week period between August 23 and September 7 in 1952, an abnormal jump in numbers from 50 to 1,010 pintails occurred, followed by a sharp reduction during the next two-week period. Local movements to another of the Hawaiian Islands may have caused this decline, but the Hawaiian chain may serve only as a stopover point for some of the pintails that continue on to points farther south, as discussed later. The shoveler pattern remained normal with a gradual, steady build-up.

The peak period for pintails on Maui varies greatly but usually precedes the peak for shovelers. It appears that movement between islands by the pintails is of common occurrence and this probably accounts for the fluctuating numbers on the island of Maui. The shovelers, for the most part, remain on Maui throughout their stay in the Territory.

Mass departures are the rule for both pintails and shovelers; 80 per cent or more of the birds usually leave within a one-week period.

Local movements.—Our first answer to the question of whether or not ducks in general remain on the same island throughout the season came on December 16, 1952, when a pintail banded two months previously on Maui was retrapped on Oahu. During this study, four more pintails were banded on Maui and retrapped on Oahu. Other movements noted were: Maui to Hawaii, two pintails; Oahu to Maui, two pintails; and Oahu to Hawaii, one pintail.

RELATION TO CONTINENTAL POPULATION

Band Recoveries

Twelve pintails banded in North America have been trapped or recovered on the Hawaiian chain. One was taken on Kauai, three on Maui, six on Oahu, and two on the island of Hawaii. The points at which each was originally banded are shown on the map in Fig. 2. Five were birds of the year, six were birds banded the previous year as immatures (and may have wintered in Hawaii the preceding year), and one had been banded as an adult.

Pintails alone have been trapped in sufficient numbers to have produced recoveries or returns. The numbers banded each year and the subsequent recoveries on the mainland are shown in Fig. 2 and Fig. 3. Because of the small numbers involved, the data have not been broken down into sex or age groups. However, it should be pointed out that the Hawaiian bandings represent a

	1949–1950	1950–1951	1951–1952	1952–1953	1953–1954	1954–1955	1955–1956	Percent Recovered
No. Banded	114	8	420	1,172	718	379	-	
Recovered First Year	-	0	-	12	13	32	14	2.5
" Second "	-	-	4	-	3	6	9	0.8
" Third "	-	-	-	2	-	3	2	0.2
" Fourth "	-	-	-	-	4	-	2	0.2
" Fifth "	-	-	-	-	-	0	-	0
" Sixth "	-	-	-	-	-	-	1	tr.

FIG. 3. North American recoveries from 2,811 pintails banded in Hawaii.

TABLE 3.—PERCENTAGES OF PINTAILS BANDED ON MAUI

Period	Total Flight	Per Cent Banded
1949–50	1,593	8
1950–51	1,875	0
1951–52	7,094	6
1952–53	8,226	14
1953–54	1,950	37
1954–55	2,653	14

relatively large proportion of the total flight to the islands each year (Table 3).

The cumulative recovery rate for the first year following banding was 2.5 per cent.

Is There an Hawaiian Flyway?

Much mystery has been attached to the regular appearance of wintering waterfowl in the Territory. Is it only accidental that they happen onto the islands after being blown away from the Pacific Coast of North America, or do they deliberately set out from their breeding grounds and actually fly along a definite course to the Hawaiian Islands?

It would appear that migratory birds, especially the American golden plover (*Pluvialis dominica*) and ruddy turnstone (*Arenaria interpres*), which winter regularly in Hawaii, take advantage of prevailing winds over the North Pacific Ocean area when making flights to and from North America and the Hawaiian chain. The "taking-off" point for ducks coming to Hawaii seems to be the coast of California where the trade winds originate.

Of the millions of ducks reported in the Pacific Flyway, only about 10,000 continue on to the Hawaiian Islands to winter, and only the pintail and shoveler come to us in any numbers. Of the many thousands of ducks banded in North America only 13 have been found in Hawaii—most of them being immature pintails trapped in northern California; one was known to have been hatched in Alberta. Cloacal examination for age determination was not used in the present study, but the full-plumaged drake pintails arriving in fall clearly show that our flights include many adult birds. This is further shown by the return of 18 pintails to our traps one or more years after we banded them (Fig. 4). It seems that some adult pintails deliberately return to Hawaii to winter and are not merely blown off course.

For many pintails, Hawaii may be only a stopping-off point on a much longer migration (Table 4). L. T. Craig in a letter to John E. Chattin states that "pintails regularly migrate to the northern Cook group and are recognized as regular visitants by the natives."

Very seldom do migratory ducks remain to summer in Hawaii, and there is no evidence of their nesting here. Of the 2,811 banded ducks that presumably left the Territory for North America, 107 (3.8 per cent) have been either retrapped, shot, or found dead on the continent. It is assumed

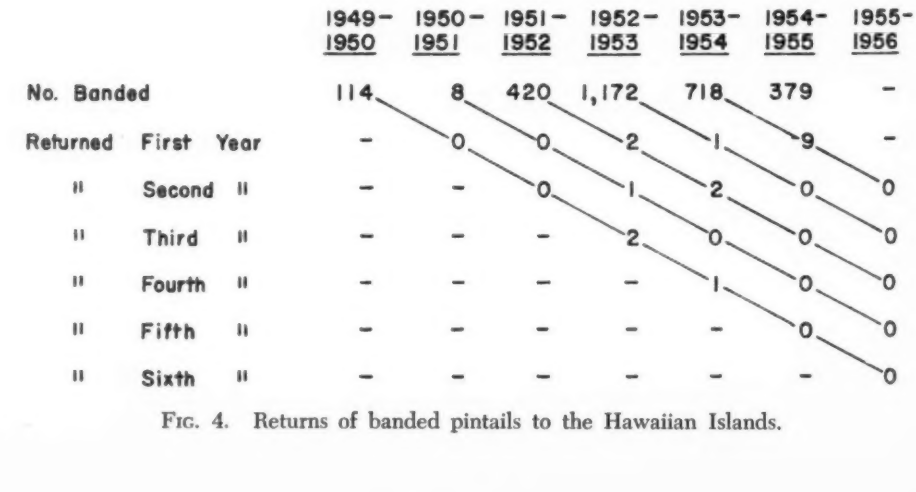

FIG. 4. Returns of banded pintails to the Hawaiian Islands.

TABLE 4.—PACIFIC PINTAIL RECOVERIES OTHER THAN FROM THE TERRITORY

Band No.	Banding Site	Date Banded	Sex	Age	Point Recovered	Date Recovered
40-693910	Brigham, Utah	Aug. 15, 1942	M	–	Palmyra Island	Nov. 5, 1942
41-679296	Tule Lake, Calif.	Aug. 16, 1949	F	A	Penrhyn Island, N. Cook group	Nov. 15, 1949
506-09761	Maui, T.H.	Oct. 16, 1952	F	A	Pukapuka Island, N. Cook group	Nov. 26, 1952
576-08510	Suisun, Calif.	Oct. 16, 1956	M	I	Washington Island, Line Island group	Dec. 13, 1956

that their return flight from Hawaii to the mainland followed the course of the "trades," as those winds turn north and become known as the "westerlies." The westerlies reach North America in an extended area from Crescent City, California, to the Gulf of Alaska.

Two spring recoveries show the nature of the west-to-east flight. A pintail banded at Kanaha Pond, Maui, on January 20, 1953, was found dead and washed ashore on April 26, 1953, at Point Vincente, Los Angeles County, California. This bird either battled the trade winds all the way to Point Vincente, or followed the more usual pattern of returning with the westerlies and, upon reaching the northern Pacific Coast, flew south in a reverse migration. Another pintail banded at Kanaha Pond, Maui, on January 26, 1954, was found dead sometime before May 19, 1954, at Nipawin, Saskatchewan, Canada.

MANAGEMENT PROBLEMS

The hunting of waterfowl on the islands was stopped by the advent of military rule in 1941 and was not resumed after World War II, in spite of some agitation for it on the part of local sportsmen. The season was deliberately kept closed for two reasons: (1) to protect the nearly extinct Hawaiian duck (koloa) (*Anas platyrhynchos wyvilliana*), which cannot be easily distinguished in flight from the female pintail; and (2) to protect migratory ducks until certain facts can be learned about their migration.

Results of this study strongly suggest that there is definitely a core of migrants that returns to the islands and perhaps leads other ducks to the Territory. Should an open season be declared, and the legal and illegal kill prove to be high, it could nearly wipe out the duck population of the Territory. There are approximately 4,000 licensed hunters in the Hawaiian Islands, and if one-half of these participated in a single duck hunt in 1954–55 and shot 2.2 ducks per man, every duck in the Territory would have been killed in that hunting season.

Water areas frequented by waterfowl are now, however, at a premium. Some landowners are jealously guarding their lands and reserving their hunting for employees, friends, and guests who will not abuse the privileges. Were a waterfowl season declared, it is possible that 90 per cent of the hunters would not be able to "shoot ducks" for the simple reason that they do not have access to a hunting area.

If a limited hunting season were to be declared, the island of Kauai and the Kailua section of Oahu should remain closed, because there is found the remnant population of the native duck, koloa. This species so closely resembles females of the other migratory waterfowl visiting the Territory that it would be quickly exterminated if shooting were permitted in its range.

In the Hawaiian Islands, shallow swamplands located at low elevations seem to be preferred by migrant waterfowl. At present the 230-acre Kealia and 60-acre Kanaha areas on Maui have been set aside as refuges and provide adequate protection on this island.

On Oahu, drainage and reclamation of swamp areas have kept up at an accelerated rate. An attempt to drain the 210-acre Kaelepulu pond was foiled by fall rains in 1954, but further attempts will be made.

This is most unfortunate, because the area is an ideal refuge, with loafing bars, sufficient water, and a prodigious amount of food-producing plants. A plan to eliminate botulism should be worked out. If Kaelepulu were drained, the majority of the waterfowl would concentrate at Salt Lake and the Kaneohe Fish Ponds, two areas of about 325 acres that at present afford protection to waterfowl because the former is treated as a sanctuary by its owners, and the latter is on a U.S. Marine Air Station.

On the island of Hawaii, waterfowl are not plentiful because good water areas are scarce. Birds are concentrated at the Lanai pond, Loko Aka ponds, and at Waipio Valley. Both the Lanai and Loko Aka ponds, which total 55 acres, are located within the city limits of Hilo, and thus receive protection from shooting. The birds frequenting Waipio (15 acres) may be subjected to gunfire from the residents of the area only, for there is but one access road; it can be easily checked by enforcement personnel.

The island of Kauai does not, ordinarily, support many migrant waterfowl. During this six-year study, residents of Kauai reported "large flocks" of ducks only during the 1952–53 wintering season, a time when about 10,500 ducks wintered in the Territory. Fred B. Conant, manager of the Princeville Ranch, told the author that there were about a thousand ducks in the Hanalei valley during the winter of 1952–53. On that island, a concerted program of protecting the native koloa duck should be the primary concern of the Board of Commissioners of Agriculture and Forestry and the general public. The koloa duck, like the rare Hawaiian goose (*Branta sandvicensis*), has steadily declined on all islands because of drainage and indiscriminate shooting by local residents. Residents should be made aware of the critical position of this species. Judges sentencing persons guilty of shooting this tame bird should impose severe fines in order to discourage their indiscriminate killing. Patrols of the warden staff should be so arranged as to cover areas that are used by these birds a goodly share of the time.

For its size, Molokai supports a good number of ducks. Along the lee side of the island, ponds that are maintained for harvesting of fish have proved to be very suitable to migratory ducks. Much daily movement has been reported between the 14 ponds ranging from 6 to 65 acres on the eastern and the 2 ponds that total 55 acres on the western portions of the islands. The ponds on the western part of the island in particular have a perimeter of very suitable food-producing plants that are heavily utilized. Because of the small size of the island, violations are readily noticeable and are reported to the warden.

Most of the areas frequented by waterfowl are interspersed with stands of both the spike and bull rushes (*Scirpus maritimus* var. *digynus*) (*S. validus*). The submergent type of vegetation is sorely lacking in the pond areas of the Territory.

SUMMARY

The number of waterfowl in the Territory of Hawaii recently recorded during the January inventory has ranged from a low of 2,034 in 1950 to 10,462 in 1953. The pintail and the shoveler are the principal wintering species. Pintails arrive between August 20 and September 18; shovelers, a week later. Pintails usually leave during the month of March, and the shovelers during the last week in April and the first week in May. Retrapping shows that pintail movements between islands occur. Eleven pintails banded in the northern half of California and one in Alberta, Canada, have been retrapped in the Hawaiian chain. Of 2,811 ducks banded in Hawaii between 1949 and 1953, 107 were either retrapped, shot, or found dead on the North American continent. A concentration of these recoveries was centered around the San Francisco Bay area. Eighteen of the banded pintails returned to the Territory and were retrapped one, two, three, or four years later. One of the adult female pintails banded on Maui was found 41 days later on the North Cook group of islands, a distance of about 2,100 miles. Waterfowl and shorebirds probably take advantage of the tradewinds and

westerlies when negotiating the flight to and from Hawaii. The Hawaii-bound pintails probably depart from California. There appears to be a "core" of pintails that returns to the Territory each year and probably leads the other ducks. The number of waterfowl wintering in Hawaii is not sufficient to provide sustained hunting; a single open season might jeopardize the whole flight.

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COMPARATIVE MOVEMENTS OF BOBCATS AND COYOTES AS DISCLOSED BY TAGGING

Weldon B. Robinson[1] *and Eugene F. Grand*[2]

Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service

During recent years bobcats (*Lynx rufus*) have increased over much of their range in the Western States, especially where coyotes (*Canis latrans*) have been controlled. The possibility that the upsurge of cats is in some way connected with the decline of coyotes is interesting, but is beyond the scope of this discussion. The purpose of this paper is to summarize recent bobcat tagging studies carried out by the U.S. Fish and Wildlife Service and to compare the movements of bobcats with those of coyotes.

Although classed as a predator along with the coyote, the bobcat generally is not as destructive. In our experience, the former may be a problem over wide areas, whereas the latter is more likely to be troublesome locally in areas of concentration, on lambing grounds, near ranches, or in localities where such game birds as the chukar partridge (*Alectoris graeca*), the red-legged partridge (*A. rufa*), or the wild turkey (*Meleagris gallopavo*) have been recently introduced. Even so, with the increase of cats, problems have arisen in controlling their depredations. Trapping is the most effective means of reductional control, but is slow and expensive. Hunting with dogs has even more limitations. Poisoning, coyote-getters, or hunting with airplanes—the methods most effective against coyotes—have not been effective against bobcats.

For a time it appeared that the bobcat problem would get out of hand over much of the West; and in casting about for a solution, it became apparent that little was known about the movements of these animals. To obtain information on movements that would be useful in control work, the U.S. Fish and Wildlife Service, through its Denver Wildlife Research Laboratory and Branch of Predator and Rodent Control, carried on a tagging study in Montana from 1954 to 1957 in which 81 bobcats were tagged and released, and from which there were 48 recoveries.

The laboratory furnished the tags and record forms, and the senior author supervised the study and prepared the manuscript. The Montana mammal-control agents, under the direction of the junior author and Assistant District Agent W. D. Bloys, tagged and released the cats in connection with

[1] Biologist, Branch of Wildlife Research, Denver 2, Colorado.

[2] District Agent, Branch of Predator and Rodent Control, Billings, Montana.

their regular duties. The field men performed the major portion of the work, and much ingenuity on their part was required in working out procedures. Those who did the tagging, and to whom our grateful thanks are extended, are: Assistant District Agents E. E. Seyler and Clayton B. Zook, and Mammal Control Agents Earl White, Everett R. Whiteaker, Nick Lafrantz, Edgar F. Knapp, Ralph Otterman, David C. Fraser, and Jim Widdekind.

The first cat was tagged in October 1954, and the last in January 1957. We had hoped to mark more animals, but a decline in bobcat numbers and an increase in coyote depredations, which required more of the field men's time, resulted in so few bobcats being tagged that the study was terminated. The data, although not as extensive as desired, nevertheless are adequate to show the nature of bobcat movements.

The study was carried out in eastern and north-central Montana. Seventy of the 81 bobcats captured for tagging were taken in steel traps, 9 were treed by dogs, while 2 were box-trapped. Much of the steel-trapping was done during the winter and, although an attempt was made to release only those cats with minor trap injuries, some animals later turned up minus toes or the entire foot. Since other bobcats were crippled temporarily and it was impossible to determine which injuries affected movements, the records of all animals recovered were tabulated. Notations were made, however, on those with permanent injuries, even though the wounds had healed.

Numbered aluminum ear-tags were used on 78 of the bobcats. At first it was feared that they might claw the tags from their ears, so for further identification the tip of the opposite ear was removed. This proved to be unnecessary, as only one cat with a cropped ear later turned up without its tag. Tattooing also was tried on three of the animals but was unsatisfactory, as the ear of one cat, when recovered, had to be skinned for the number to be read.

TABLE 1.—BOBCAT TAGGING AND RECOVERY RECORDS

Tag No.	Age[1]	Sex	Date[2] Tagged	Date[2] Recovered	Distance Airline Miles	Tag No.	Age[1]	Sex	Date[2] Tagged	Date[2] Recovered	Distance Airline Miles
526	A	F	10-13-54	±11-1-55	7	577	A	M	1-28-55	11-28-55	10
502	A	M	10-23-54	4-13-55	5	519	A	M	1-29-55	3-3-55	2½
503	A	F	10-23-54	12-10-54	4½	528	A	M	2-1-55	2-15-55	0
505	A	M	11-2-54	10-18-55[3]	2	591	A	M	2-1-55	2-16-55	0[5]
507	A	F	11-27-54	2-2-55[3]	¼	592	Y	M	2-1-55	3-10-55	½
				3-3-55	2½	594	A	M	2-2-55	1-28-56[4]	19
551	A	F	12-7-54	12-11-54	⅒	562	Y	F	2-9-55	2-8-56	1
552	A	M	12-7-54	9-10-56	9	563	A	F	2-9-55	2-23-55	1½
510	Y	F	12-11-54	1-4-55	⅛	529	A	F	2-15-55	1-24-56[4]	2
555	Y	F	12-16-54	12-26-54	4½	596	A	M	2-16-55	±11-13-55	4½
513	A	F	12-20-54	1-1–15-55[4]	6	698	A	?	3-17-55	4-1-55[4]	¼
514	A	F	12-20-54	2-4-55	1¾	599	A	M	3-17-55	4-14-55	½
601	A	F	12-20-54	3-2-55[4]	2	1	A	M	3-21-55	±3-28-55	2
515	A	M	12-21-54	2-1-55[4]	4	2	Y	F	3-21-55	9-24-55[4]	2
603	A	M	12-22-54	2-15-55[3]	¾	521	A	F	3-30-55	10-25-56	6
556	Y	F	12-23-54	1-3-55[3]	¼	4	Y	F	3-30-55	±11-18-55	19
				1-28-55[4]	¼	6	Y	M	4-1-55	12-10-55	23
557	A	F	12-29-54	3-9-55[4]	2¼	531	A	M	8-26-55	3-11-56	3¼
559	A	M	1-3-55	2-1-56	20	7	A	M	9-14-55	10-17-55	¼
516	A	M	1-22-55	10-22-55[3]	⅒	566	A	M	10-13-55	7-12-56	7
				3-8-56[4]	½	523	A	F	10-25-55	3-26-56[3]	3¼
517	A	?	1-24-55	1-31-55[4]	¼	524	A	M	10-25-55	12-10-55[4]	2½
561	A	F	1-27-55	2-7-55[3]	4	26	A	F	12-17-55	12-23-55	3½
				1-30-56	3	31	A	F	1-3-57	3-25-57	0

[1] A = adult; Y = young (kitten). [2] Month, day and year. [3] Captured and released again.
[4] Crippled as a result of initial trapping. [5] 25 feet.

BOBCAT MOVEMENTS

Thirty-one of the tagged cats were retaken by the predator control agents who did the tagging, while the other 17 recoveries were by individuals not connected with the Service. Seven of the animals were retrapped, or treed by dogs, and released again; 41, including 4 released the second time, were killed. The recovery intervals ranged from 4 days to 21 months.

The tagging and return data for the cats that were recovered are listed in Table 1, and their movements on a time basis are shown in Table 2. The mean distance between points of tagging and recovery was 4.1 airline miles and the median was 2.0 miles. Seventeen of the returns were of animals retaken within one mile of the release points, and 11 of these were within ¼ mile. One mature cat was recaptured in the same trap at the same location two weeks after tagging; another one was retrapped at the same place and even with the same bait nearly three months after release; and still another was retrapped 25 feet away 15 days later.

TABLE 2.—MOVEMENTS OF BOBCATS

Distance Moved (Miles)	Distances Moved by Months						
	0–3	4–6	7–9	10–12	13–15	16–18	19–21
0-1	14***	1*	1	1	–	–	–
2	4*	1*	–	2*	–	–	–
3	4**	–	–	1	–	–	–
4	3*	1	1	–	–	–	–
5	2	1	1	–	–	–	–
6	1*	–	–	–	–	–	1
7	–	–	1	–	1	–	–
9	–	–	–	–	–	–	1
10	–	–	–	1	–	–	–
11	–	–	–	1	–	–	–
19	–	–	1	1*	–	–	–
20	–	–	–	–	1	–	–
23	–	–	1	–	–	–	–

* Animals crippled (one for each asterisk) by being trapped for tagging.

Thirty-eight of the 48 returns were at points 5 miles or less from the tagging locations, and 44 of the animals traveled no more than 10 miles. The other four moved greater distances: one was killed 19 airline miles away a year after tagging; another moved the same distance in 8 months; a third traveled 20 miles in 13 months; and the maximum movement was by an animal trapped 23 airline miles from its tagging point eight months after release.

Adults outnumbered kittens 65 to 16 in tagging and 39 to 9 in recoveries, yet two of the four longest movements were made by the younger animals. Too few kittens were taken for a comparison of the distances traveled by adults and juveniles to carry much weight; the mean figures, however, are 3.7 miles for 39 mature bobcats and 5.6 miles for 9 kittens.

COYOTE MOVEMENTS

A picture of coyote movements for comparison may be obtained from previous studies carried out by the Denver laboratory. In the past, two tagging programs with coyotes were conducted: 197 were marked and released in Wyoming and other western states from 1931 to 1940 by Noble E. Buell, B. F. Lowery, S. E. Aldous, and various field men of the Branch of Predator and Rodent Control (Garlough, 1940); and 419 were tagged in Yellowstone Park and vicinity from 1945 to 1949 (Robinson and Cummings, 1951). As set forth in Fig. 1, there are 89 usable recoveries from the Wyoming study and 212 from Yellowstone. The 212 records include 178 usable recoveries tabulated by Robinson and Cummings (*ibid.*), 2 records that were received after publication of that paper, and 32 of 34 recoveries that were not included in that compilation because the animals (all retaken within 3 miles of the tagging points) were recaptured so soon after release that they had had little opportunity to move. Similar short-term recoveries of bobcats are herein reported, hence the discarded coyote records are included.

Although coyotes from both areas outdistanced the cats, the Wyoming coyotes generally traveled farther than did those from Yellowstone. The difference in the movements of the two groups is doubtlessly a reflection of conditions of study and other

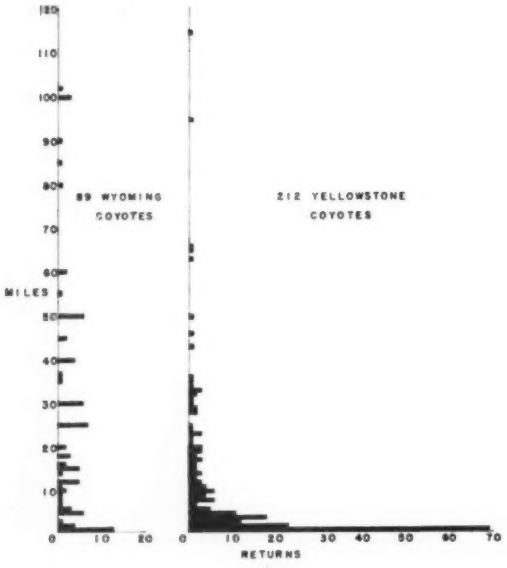

FIG. 1. Returns from coyotes tagged in Wyoming and other states, 1931–40, and in Yellowstone National Park and vicinity, 1945–49.

factors. The purpose of the tagging in Wyoming was to determine the movements of these predators out of some of the more inaccessible denning areas, and nearly all of the marked animals were tagged as pups taken from dens. Eighty-seven of the 89 returns were of younger animals, and their movements should reflect maximum dispersals. The animals literally spread over 100 miles of territory in all directions. Their mean movement of 25.4 miles exceeded the maximum of the bobcats, and the median drift of 16 miles was surpassed by only four cats.

In the Yellowstone study, intense recovery efforts in the area of tagging and a 1080-station control program at distant points beyond the park boundaries favored the recovery of tagged animals at nearby locations. Nevertheless, their mean and median movements of 9.4 and 4 miles, respectively, were about twice as great as those of the cats.

The shorter movements of the Yellowstone coyotes also may be due in part to the fact that nearly one-third of the recoveries were of animals that were mature when tagged. The median recovery distance for 66 adults was 4 miles and for 146 pups, 3 miles; the mean figures were 7.0 miles for the adults and 10.5 miles for the pups. Although more of the pups were recovered near their tagging points, their average movement was greater than that of the older coyotes.

BOBCATS VS. COYOTES

The mean recovery distance of 24 female bobcats was 3.2 miles and of 22 males, 5.3 miles. In the Wyoming study, the mean figures were 21.4 miles for 38 female coyotes and 28.5 miles for 51 males. Thus the data from both these experiments, as well as from tagging studies with other carnivores with which we are familiar (Arnold, 1956; de Vos and Guenther, 1952; Hawley and Newby, 1957; McCabe, 1948; Miller, *et al.*, 1955; Ritcey and Edwards, 1956; and Sheldon, 1950), indicate that males outdistance females. The Yellowstone coyote data, however, involving 178 records, were conflicting (Robinson and Cummings, *op. cit.*). In the present compilation, with the addition of 34 records to bring the number of recoveries to 212, the mean recovery distance of 102 females was 11.1 miles and of 110 males, 7.9 miles. The median distances were 5 miles for females and 2 miles for males. The maximum of 115 airline miles was by a female killed with her pups when she was two years old, and four of the five longest movements were by females. At the other extreme, in recoveries within one mile of the release points, males outnumbered females 42 to 27. Could it be that the pattern of movement by sexes might be different in a population, such as that of coyotes in Yellowstone, that has relatively few artificial controls and probably has reached the upper density level for its habitat?

The combined data from Wyoming and Yellowstone should give a more accurate picture of coyote movements than either study alone. Hence, in Fig. 2 the data from the two areas are shown with the bobcat returns. The mean recovery distances were 4.1 airline miles for the 48 cats and 14.2 miles for the 301 coyotes. The median distances were two and five miles, respectively.

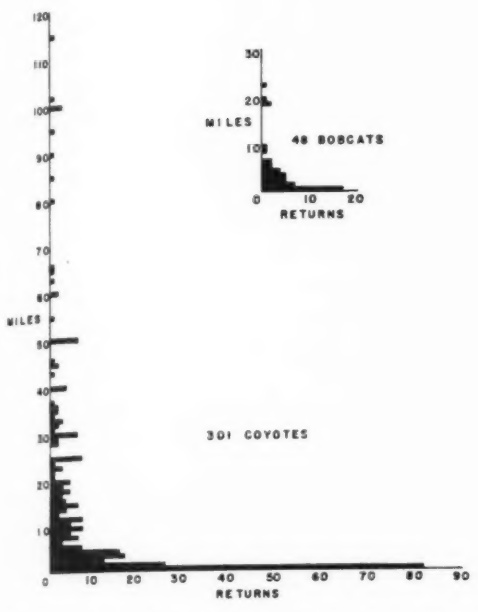

FIG. 2. Comparison of movements of Montana bobcats and Wyoming and Yellowstone coyotes.

The percentages of recovery within one mile of the release points were 35 for cats and 27 for coyotes. At five miles, the figures are 79 per cent for cats and 52 per cent for coyotes; at 10 miles, 92 per cent for the bobcats and 63 per cent for the coyotes. Sixty-two, or 21 per cent, of the coyotes moved farther than 23 miles—the maximum recovery distance of the cats.

Even though most of the cats were tagged as mature animals and most of the coyotes as juveniles, the comparison as set forth in Fig. 2 would seem to be the best that can be made of the movements of the two species at this time. Since trapping methods did not seem to favor the capture of one age class of bobcats over the other, the cats taken for tagging should have been fairly representative of the existing population. If errors occurred, they probably were in identifying mature cats and kittens in the field rather than in trapping procedures that resulted in the capture of one age group more than the other. Thus, the pattern of movement of the tagged bobcats should have been the same as that of the untagged population as a whole.

This may not be so with the coyotes. Since more of these animals were taken as pups from dens than were trapped, the methods of capture would result in relatively more pups than adults being tagged. Fish and Wildlife Service trapping records for control purposes show that the coyote population in the fall—when most of the movement occurs—may at times be made up of as high as 60 to 70 per cent young of the year; even so, the tagging sample, with its ratio of 77 per cent pups to 23 per cent adults, contains too many of the younger animals, which have greater tendencies to disperse. The disparity, however, may be offset, at least in part, by the fact that most of the records came from Yellowstone where, as explained previously, intense recovery efforts in the area of tagging and a 1080-station control program at distant points beyond the park boundaries favored tag recoveries from nearby locations.

A further comparison can be made of the movements of the older animals alone. The mean recovery distances were 3.7 miles for 39 mature bobcats and 6.9 miles for 68 mature coyotes; the median distances were 2.5 miles for cats and 4.0 miles for coyotes. The longest movements were 20 miles over a 13-month period for a cat and 43 miles over a 26-month period for a coyote. The latter record came from the Yellowstone area, and possibly was the seasonal movement of an animal that had drifted downcountry in the fall and, had it not been killed, would have returned to higher country in the spring (Robinson and Cummings, *op. cit.*). Whether or not bobcats also move seasonally is unknown, but the records of the one that drifted 20 miles (tag no. 559, Table 1) and of other mature cats recovered during the same seasons a year later (nos. 526, 577, and 594) suggest that a change of home range may be involved.

MANAGEMENT IMPLICATIONS

It is apparent that coyotes move about more than cats, and this and other findings from the tagging experiments can be applied to the control problems that prompted the studies. The bobcat problem that has

loomed so large in recent years is largely being met through concentrated trapping in the areas of trouble. This does not mean that more efficient methods would not be considered if available, but that trapping is still the best way of controlling bobcats, and nothing better is in sight.

The tagging experiences may explain why trapping is more effective for the control of bobcats than it ever has been for coyotes in the same areas. First, coyotes are more difficult to trap, and they learn faster. The fact that two mature bobcats walked back into steel traps at the same places where they were trapped a few weeks earlier illustrates their lack of caution. None of the far greater number of coyotes released from traps did this, and it is difficult to imagine a coyote being so unwary! Secondly, after bobcats have been removed from an area, the trapper can shift his attention elsewhere until other cats move in. In our experience, this may take one or two years.

In contrast, because coyotes repopulate an area faster, are more cautious, and adjust quickly to changing conditions, control work must be continued in the same areas of coyote depredation year after year until eventually a population of resident animals is built up that has learned to avoid the current methods. This has happened in the past with traps and strychnine stations, and is now occurring in parts of the West with coyote-getters and 1080 stations.

Because trappers literally must "go to the cats" to capture them, local control would have less effect on over-all numbers of bobcats than on a species with a wider range. And even though coyotes travel more, there will always be areas where they will maintain their populations—and they no doubt will continue to move into localities where they are less welcome and to fight see-saw battles with man's control weapons. Livestock men, as well as game managers who are interested in reductional control, should adjust their thinking to the fact that both coyotes and bobcats—even though limited in numbers in many localities—are here to stay.

SUMMARY

Eighty-one bobcats were tagged in Montana from 1954 to 1957, and there were 48 recoveries. Seven of the animals were recaptured and released again, and 41, including 4 released the second time, eventually were killed. Seventeen of the recoveries were within 1 airline mile of the release points, 38 were within 5 miles, and 44 were within a 10-mile radius. The maximum movement was 23 miles. In previous studies in which 616 coyotes were tagged, there were 301 comparable recoveries. The mean recovery distance of these coyotes was 14.2 miles, as compared to 4.1 miles for the bobcats; the median distances were 5 and 2 miles, respectively. The maximum coyote movement was 115 miles, and one out of five of these animals traveled farther than the most nomadic cat. The fact that coyotes move about more than bobcats has important application in control work.

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STUDIES ON THE LIFE HISTORY OF ALSEA RIVER STEELHEAD

Donald W. Chapman[1]

Oregon Cooperative Wildlife Research Unit,[2] Corvallis, Oregon

A comprehensive life history study of the steelhead trout (*Salmo gairdneri gairdneri*) was initiated in 1954 by the Oregon Cooperative Wildlife Research Unit at the request of the Oregon State Game Commission, the agency most concerned with management of the species in the state.

The initial phase of the study involved analysis of steelhead scale samples secured from drainages throughout Oregon (Bali, 1957). Since this work was general in scope, it was desirable in the present study that a particular stream be investigated. The Alsea River was chosen for this purpose, because it was typical of Oregon coastal streams and because of its proximity to Oregon State College, where the Research Unit is based.

The Alsea River rises on the west slope of the Coast Range and flows into Alsea Bay near Waldport. The area of the drainage basin (Fig. 1) is about 450 square miles, and the terrain therein is generally rough and steep, with little flat land other than small portions found intermittently along the main river. Some of the forest lands are newly logged, some are covered with hardwoods, and others are in some stage of coniferous growth.

The river estuary is about 10 miles in length and enters the Pacific Ocean at Waldport. The lower portion of the bay is quite saline, but upper reaches grade into fresh water toward the head of the tidal influence. No closure of the river mouth occurs in summer. Four major tributaries contribute most of the steelhead trout production in the drainage. These streams are Five Rivers, Fall Creek, and the North and South forks. Drift Creek also has an excellent steelhead population, but is not considered a part of the Alsea drainage in this study.

A game-commission hatchery is located on the North Fork. Adult steelhead are taken near the hatchery in an upstream trap, held until ripe, then spawned artificially. All smolts released in the Alsea River are reared at this installation.

The main-stream river bed and the stream bed in the lower portions of Five Rivers are composed largely of bedrock. The North and South forks, Fall Creek, and upper Five Rivers each have a greater proportion of gravel and rubble areas than bedrock.

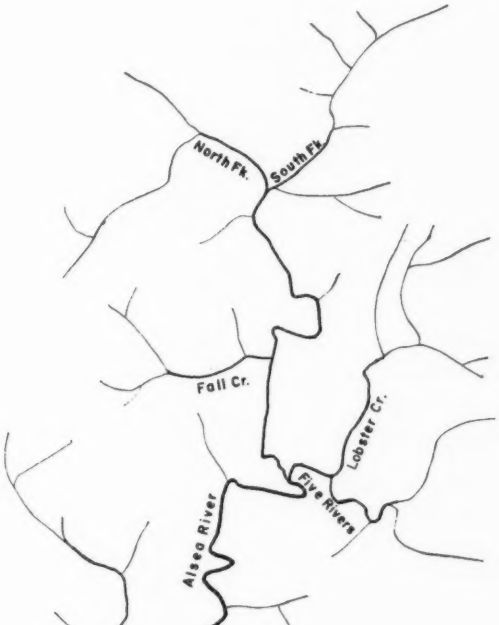

FIG. 1. Principal streams of the Alsea River basin.

[1] Now employed by the Committee on Natural Resources, State of Oregon, 317 Snell Hall, Corvallis, Oregon.

[2] Oregon State Game Commission, U.S. Fish and Wildlife Service, Wildlife Management Institute, and Oregon State College co-operating.

Water flow of the river is characterized by the great seasonal fluctuations common to Oregon coastal streams. Runoff is usually heavy during the period from October through April but decreases markedly in the summer months. Lowest flows, as recorded about 3 miles east of Tidewater, occur in September and averaged 114 cubic feet per second in that month for the years 1949 to 1955. This low mean flow may be contrasted with the runoff during January, which averaged 4,923 cubic feet per second for the same 7-year period.

SAMPLING AND SCALE-ANALYSIS PROCEDURES

Downstream traps of the inclined-plane type were successfully used to take smolts on all tributaries. A large "V" trap was used in the lower river to recover marked fish. Tattoos (Chapman, 1957b) and liquid latex injections (Chapman, 1957a) were used to mark smolts taken in tributary traps or hatchery smolts experimentally released. Gray dots tattooed along the ventral surface of smolts provided combinations sufficient to designate four trap locations and 30 different marking days.

Downstream traps were checked daily. Steelhead smolts were measured, tattooed, and scale samples were taken. Scales were removed from the left side of the fish between dorsal fin and lateral line.

Adult steelhead scale samples were procured through creek checks and commercial fish buyers and from fish taken in an upstream adult trap operated by the Oregon State Game Commission on the North Fork. Scales from adults were taken from the same body area as that used for juveniles. This is the "key" area described by Maher and Larkin (1954).

Lengths of all fish were measured to the nearest ¼ inch, and adult weights were taken to the nearest ¼ pound as recorded on a spring scale. Sex of adults was determined by inspection of such characteristics as body conformation, head and mouth shape, and appearance of the genital opening.

Adult scales were read at least twice—more, if readings were suspect. Juvenile samples were read only once, unless the validity of the initial reading was doubtful. Measurements to annuli were taken from focus to the outside of the annulus at the last constricted circulus. Measurements were taken to each annulus, to the point at which the adults had entered salt water as smolts, and to the scale margin. All radial measurements were made on the anterior field of the scale at a fixed angle from center.

Ages are designated in this paper in the manner used by Maher and Larkin (*ibid.*). By this method, for example, a steelhead that had spent two winters in fresh water and one winter and two summers in salt water would be designated as 2/2. This fish would have formed a second salt-water annulus in the winter of capture, had the spawning migration not been made.

Juvenile steelhead ages are designated with numerals on the left of the virgule only, as 1/, 2/, or 3/. Adults designated by salt-water age appear as /1, /2, /3, or /4.

Steelhead that have spawned previously are denoted by placing an "S," followed by a period, after the salt-water year of spawning, then placing the salt-water year of capture after the spawning designations. For example, a 2/2S.3 fish is one that spent two winters in fresh water, entered the sea, spawned at the end of the second salt-water year, and was captured near the end of the fifth year of life.

For the sake of brevity, fish of hatchery origin may be designated as marked fish, since most steelhead released have been marked by removal of both ventral fins and the adipose fin. Brood year in this paper is defined as the year in which a particular age class of fish was hatched. It is impractical to use the year of adult winter steelhead migration as the "brood year" of the resulting progeny, since adults may enter fresh water from late October through April.

Back-calculation of growth of adult steelhead is complicated by two factors: marginal absorption of the scale and the possibility that scale growth and fish growth are not proportional at all ages. Absorption is common on scales from adults, particularly as the spawning time is approached. Plots

of weighted means of fish length and scale size showed that scale growth is roughly proportional to fish growth, at least up to a fish length of about 30 inches. Samples were inadequate beyond this length. Mottley (1941) found that scale size provided an unbiased estimate of length of the rainbow trout (*Salmo g. gairdneri*) of Paul Lake, British Columbia. Maher and Larkin (*op. cit.*) used scale diameters to predict fork lengths of steelhead at juvenile sizes by means of a log-log regression of fork length on scale diameter.

Scale sizes and fish lengths of 400 juvenile samples were tabulated and a regression of fish lengths upon the logarithms of scale radii was calculated. No attempt was made to back-calculate growth of individual fish, but rather for groups of fish only—all fish in the samples of one brood year for example.

ANALYSIS OF ADULT SAMPLES

Analysis of 978 scale samples from adults of wild origin revealed that over 90 per cent of the fish remained in fresh water for at least two winters (Table 1) before migrating to sea as smolts. About 52 per cent were 2/2, 21 per cent were 2/3, 13 per cent were 3/2, 4 per cent were 2/1, and all other patterns were 10 per cent of the total sample. Since these results are similar to those of workers in California (Shapovalov and Taft, 1954), in Oregon (Bali, *op. cit.*; Sumner, 1945; Long and Griffin, 1937), in Washington (Pautzke and Meigs, 1940), in British Columbia (Maher and Larkin, *op. cit.*), and in Idaho (Whitt and Pratt, 1955), it can safely be stated that, throughout its range, the steelhead trout usually spends at least two years in fresh water and two summers at sea. Exception to this can be found in the work of Neave (1940), who found that 60 per cent of Cowichan River steelhead migrated to sea as yearlings.

TABLE 1.—LIFE HISTORY OF ADULT WILD FISH (WINTERS OF 1951–55)

Years in Salt Water	Years in Fresh Water			
	1	2	3	4
1		39†	13	1
		4.0	1.3	0.1
2	2	513	133	1
	0.2	52.5	13.6	0.1
3	9	213	28	
	0.9	21.8	2.9	
4	3	19	4	
	0.3	1.9	0.4	

† Upper number is fish in age group. Lower figure is percentage in age group.

TABLE 2.—LIFE HISTORY OF ALL ADULTS OF HATCHERY ORIGIN (WINTERS OF 1951–55)

Years in Salt Water	Years in Fresh Water	
	1	2
1	20†	4
	8.5	1.7
2	112	66
	47.5	27.9
3	24	5
	10.2	2.1
4	4	1
	1.7	0.4

† Upper number is fish in age group. Lower figure is percentage in age group.

Scale patterns shown by 243 adults of hatchery origin (Table 2) were as follows: Forty-six per cent were 1/2, 27 per cent were 2/2, 9 per cent were 1/3, 8 per cent were 1/1, and all other patterns made up 10 per cent of the sample.

The shift of marked fish from 2/ to 1/ pattern was due to the fact that hatchery-reared smolts were force-fed until they were of migrant size (10 fish or less per pound) early in the second year of life, and were then released. About 33 per cent of all marked adults, however, had remained in the stream environment for a winter after release.

It was possible to segregate fish of hatchery origin from wild steelhead on the basis of scale-pattern characteristics. The freshwater portion of scales from hatchery fish (Fig. 2) was unique in the uniformity of circulus spacing, while scales from wild fish (Figs. 3 and 4) were characteristically quite

FIG. 2. Central portion of scale from a 25-inch male steelhead of hatchery origin, taken in the North Fork. The first annulus and point of entrance to salt water are marked with an "X." Note uniformity of circulus spacing from focus to end of hatchery growth. Annulus is indistinct.

variable in circulus spacing. Tests of this segregation method, using samples composed of wild steelhead and fin-marked fish of hatchery origin, resulted in an accuracy of almost 100 per cent. By means of scale analysis, it would be possible to evaluate the percentage of Alsea River adult steelhead contributed through hatchery releases, thus eliminating use of fin mutilation as an identification mark.

About 17 per cent of the 556 adult fish sampled in 1953 were repeat spawners; 81 per cent of these were on the second spawning migration, 19 per cent on the third. About 12 per cent, or 24 fish, of the 1954 sample were repeat spawners; 83 per cent on the second migration, 17 per cent on the third. About 3 per cent, or 14 fish, of the 1955 sample were repeat spawners; all fish but one were on the second migration. A low number of fish in one winter run appeared to cause a relatively low return of

repeat spawners in the next winter run. No obvious correlation could be found between spring water flows and percentage of repeat spawners returning the next winter.

A total of 133 repeat spawners had a sex ratio of one male to 2.5 females. This may be contrasted with the approximately 1:1 ratio in first spawners. Males tend to enter the river earlier, as discussed in a later section, and remain in fresh water longer than do females. Males sometimes remain in spawning tributaries to serve more than one female, as suggested by Shapovalov and Taft (*op. cit.*), and conceivably may be subject to stranding as water flows decrease in late spring. Increased time of fresh-water residence may also increase susceptibility to disease and parasites.

Four hundred and seventy-three steelhead were sexed and measured in the 1955–

FIG. 3. Central portion of scale from a 27-inch female steelhead of wild origin taken in the North Fork. The first two annuli and point of entrance to salt water are marked with an "X." Note variability in circulus spacing in fresh-water growth. Annuli are distinct.

FIG. 4. Scale from a 6.75-inch smolt steelhead taken in Five Rivers on May 14, 1956. Two annuli are marked with an "X." Note the excellent growth after the final stream annulus. This could be mistaken for "tidewater growth" on adult scales.

56 winter run entering the North Fork upstream trap. The trap was checked weekly. No change in average size of fish was evident as the season progressed. The proportion of males decreased steadily from a high of 67 per cent on January 24, 1956, to a low of about 40 per cent in early May. The proportion of marked fish was near 50 per cent early in the season, but decreased steadily to zero in May.

A decrease in percentage of marked fish, as the migration season advanced, has been a phenomenon noted by hatchery personnel each year. It is the practice of game-commission personnel to secure the winter quota of steelhead eggs first, and then to allow passage of fish upstream to the spawning grounds. This means that early steelhead are held until ripe, then stripped for eggs and milt. If the egg quota is large, the upstream passage of all fish is delayed until late in the spring. It is possible that fish of early-migrating strain are the ones that contribute most to the ultimate release of hatchery smolts, thus causing a return of marked adults early in the winter. By the same reasoning, it may be theorized that the fish that are allowed to spawn naturally are late migrants, entering the trap after the egg quota has been secured and contributing most to the late run.

Since the North Fork return of marked steelhead was not representative of the over-all contribution of these fish to the

Alsea River runs, another sample was used for the estimate of this contribution. Among all the samples procured for the life-history study were 129 steelhead taken in the estuary by commercial gill-netters and in the lower river by anglers in the winters 1953–54 through 1955–56. Ten per cent of these fish were of hatchery origin. Since marked steelhead tend to return to the river early in the winter, and since the commercial and sport fisheries both ceased before March 1, it is probable that the figure of 10 per cent was too high to be indicative of the over-all contribution of hatchery fish. Better samples and total population estimates are needed for a complete analysis of hatchery contribution.

Condition factors, or ratios of weight to the cube of length, were calculated for 263 adult fish, of which 100 were taken on the lower river and 163 at the North Fork trap. About 70 per cent of the lower-river samples were secured from steelhead caught commercially in Alsea Bay. The remaining 30 per cent were taken in the lowest five miles of river by sportsmen.

The sample was analyzed in order to determine the magnitude of the effect of sex, fresh-water age, salt-water age, origin (hatchery or wild), location of capture, and number of previous spawnings upon adult condition factors. The influences are additive (Anderson and Bancroft, 1952). Comparisons are made between various groups after accounting for the above factors. After adjustment for all other factors, males are compared to females, wild fish to marked fish, and so on, at the five per cent significance level. Comparisons are made on an "all other things being equal" basis. For instance, if repeat spawners are to be compared to first spawners, this comparison is made between groups of fish of the same sex, age, origin, and location of capture.

Fish taken in the North Fork had significantly lower condition factors than those taken in the lower river, a difference probably caused by loss of weight during the upstream migration. First spawners had better condition factors than repeat spawners. It is likely that the latter group was influenced by the spring and winter spent in the river during each previous spawning migration. For example, if two groups of steelhead are compared, one group of the 2/3 pattern and one of the same total age but with a previous spawning migration (2/2S.3), both groups being females of wild origin and taken in the North Fork, the first spawners will have a significantly higher condition factor than the repeat spawners.

There was no significant difference between condition factors of wild steelhead and steelhead of hatchery origin, or between males and females. Condition factors improved with salt-water age, but fresh-water age had no significant effect upon ultimate adult condition factors.

Lengths of the same 263 winter steelhead used in the condition calculations were subjected to an analysis of variance testing the magnitude of these influences: sex, fresh-water and salt-water age, origin, location of capture, and number of previous spawnings. Comparisons were made in the same manner as they were for the condition analysis.

At the five per cent significance level, the following groups were found to be significantly longer than their complementary groups: Males were longer than females, wild fish were longer than marked steelhead, and first spawners were longer than repeat spawners. For example, if two groups of male fish of equal total age are compared, one in the 2/2 pattern, one 2/1S.2, both groups of wild origin and taken in the lower river, the first spawners will be longer than the repeat spawners, since the latter group has been handicapped by a winter and early spring spent away from the ocean.

Length increased with increasing salt-water age, of course, but duration of fresh-water residence had no effect on adult length. Maher and Larkin (*op. cit.*) and Long and Griffin (*op. cit.*) also found that duration of fresh-water residence had no effect upon ultimate adult size. There was no significant difference between steelhead taken in the North Fork and in the lower river, or between marked fish that migrated in the season of release and those that migrated after overwintering in the stream.

ANALYSIS OF SMOLT LIFE-HISTORY PHASE

From the total catch of migrating smolts on four major tributaries, 400 scale samples were selected and analyzed. Eighty-seven per cent were age 2/, 12 per cent were age 3/, and 1 per cent was age 1/.

TABLE 3.—MEAN LENGTH (IN INCHES) OF WILD SMOLTS AT EACH TRAP LOCATION BY DATE, 1956

Trap	Time Period	Number of Fish	Mean Length
North Fork	April	38	5.79
North Fork	May 1–20	304	6.63
Fall Creek	May 2–30	686	6.23
Five Rivers	May 4–20	153	6.18
South Fork	May 4–26	156	6.20

Mean lengths of 1,337 smolts passing through all trap locations are presented in Table 3. Averages were calculated for all smolts taken in May on each tributary and Student's t test was used to compare the means. North Fork smolts were 6.63 inches long, Fall Creek fish were 6.23 inches long, Five Rivers smolts were 6.18 inches in length, and South Fork fish were 6.20 inches in length. North Fork smolts were found to be significantly longer than smolts at all other trap locations, at the five per cent significance level. These North Fork fish also had a more robust appearance than other smolts.

These differences merit some speculation. They may have been caused by one or both of two general factors. One of these is the action of such variables as grade and availability of food, water temperatures, and stream flow. The other factor is competition. The removal of adult steelhead at the North Fork trap for spawning probably has had some influence upon the number of young fish produced in the upper North Fork. A decline in returns of adult silver salmon (*Oncorhynchus kisutch*) has occurred over the last few years until only a few fish, or none at all, are allowed to pass the North Fork dam. Reduced numbers of young silver salmon and steelhead should reduce competition for food organisms and might result in an increased production of aquatic insects. This increase in production would result if the bottom food organisms had formerly been seriously overcropped—to the point of impaired reproduction, for example. The difference in growth on the four tributaries may be a constantly changing one influenced by small ecological changes.

One of the indications of growth of wild smolts between formation of the final fresh-water annulus and entrance into the sea is the number of circuli formed during this period. Table 4 shows the number of circuli formed by 400 juveniles in the 1956 pre-migration period, and the circuli counted on scales of 410 adult steelhead of several brood years.

TABLE 4.—FRESH-WATER CIRCULI LAID DOWN AFTER FINAL STREAM ANNULUS BY WILD STEELHEAD OF BROOD YEARS 1949–55, AND BY SMOLTS MIGRATING IN 1956

Brood Year	Adults Checked	Mean Circuli
1949	43	3.60
1950	36	4.19
1951	118	4.91
1952	201	4.97
1953	12	3.42
Total and mean	410	4.69

Location	Smolts Checked	Mean Circuli
Fall Creek	100	2.10
Five Rivers	100	4.44
North Fork	100	2.06
South Fork	100	3.53
Total and mean	400	3.03

The mean number of circuli for adults of brood years 1949–53 was 4.69; the mean number for smolts was 3.03. These figures mean little unless the rate of circulus formation is roughly established. Smolts taken in 1956 were found to begin forming post-annular circuli in mid-April, forming one ring each 12 to 15 days thereafter.

If environmental conditions of 1956 can be compared with those of earlier years, it appears likely that little time was spent by smolts of brood years 1949–53 in the river after formation of the final fresh-water

TABLE 5.—CALCULATED MEAN LENGTHS (IN INCHES) OF ADULTS OF WILD ORIGIN AT FRESH-WATER ANNULI, BROOD YEARS 1949–53

Where Caught	Brood Year	No. Fish	Annulus I	No. Fish	Annulus II	No. Fish	Annulus III
North Fork	1949	191	4.21	191	5.80	77	6.57
	1950	205	4.39	201	6.03	15	6.45
	1951	133	4.27	133	5.98	42	6.73
	1952	217	4.62	215	6.33	6	6.57
	1953	6	6.01	6	7.56		
Totals and means		752	4.59	746	6.09	140	6.57
Lower River	1949	38	4.21	38	5.86	1	6.61
	1950	25	4.27	23	5.87	1	6.09
	1951	12	4.09	9	5.27	7	6.22
	1952	22	4.39	24	5.86	2	5.62
	1953	4	4.69	4	6.45		
Totals and means		101	4.24	98	5.86	11	6.21

annulus. This period may have been as short as three weeks.

The possibility that steelhead smolts spend some time in estuarine waters before entering the sea has been the subject of considerable speculation by workers concerned with steelhead management. Widely spaced circuli (Fig. 4) found after the final fresh-water annulus, and often called "tidewater growth," caused this speculation. This wide spacing appears on scales from most adult Alsea River fish and is distinct from true ocean growth or from fresh-water growth in the year preceding the spring of migration. It was found that this growth takes place in tributary streams. The geographical point at which true ocean growth begins has not been determined. It may be that food availability increases sharply at some point in the estuary. Circulus spacing indicates that a sharp increase in growth occurs as the smolts reach this region of high food availability, whether in the estuary or at sea.

Examination of adult scales revealed no evidence that smolts might migrate to sea in the fall. If such a migration did occur, the first salt-water annulus would be quite close to the end of fresh-water growth. All adult scales examined had a summer of ocean growth between time of migration and first ocean annulus.

Lengths at annuli were calculated for the 400 smolt scale samples that were analyzed. Weighted mean length at annulus I was 4.28 inches; at annulus II, 5.70 inches; at annulus III, 6.16 inches. North Fork fish were consistently larger at each annulus than fish on all other tributaries.

Back-calculated lengths of adults taken in the North Fork are shown in Table 5. Mean calculated lengths at stream annuli for 101 adults taken in the lower river (Table 5) probably would be reduced if fish destined for the North Fork could have been removed from the lower river sample. The superior growth of North Fork fish would tend to increase the mean lengths of adult samples from the lower river.

An interesting trend is evident in Table 6, which shows average migration size of smolts for each salt-water age of return as adults. Steelhead that entered the sea as small smolts tended to remain there longer than did fish that went to the sea as large smolts. The same trend was evidenced by fish of hatchery origin. Marked fish released at sizes from 6.5 to 8.5 inches, were larger at migration than wild smolts.

TABLE 6.—LENGTH OF ADULTS AT TIME OF ENTRANCE INTO THE SEA AS SMOLTS. CALCULATED FROM ADULT SAMPLES TAKEN IN RUNS FROM 1952 TO 1955

Salt-water Age at Return	Number of Fish		Mean Length at Migration	
	Wild	Marked	Wild	Marked
/1	50	29	6.95	7.19
/2	639	158	6.90	7.17
/3	237	20	6.74	7.01
/4	22	5	6.61	6.98

The averages tabulated are intended to show only that, in general, smolts of small size tend to remain longer at sea than do smolts of large size. The magnitude of the effect of migration size on salt-water age has not been investigated.

In Tables 1 and 2 it was shown that about 28 per cent of all the wild steelhead sampled reached age /3 or /4, while only about 14 per cent of all marked fish reached these ages. The comparatively large mean size of hatchery-released smolts at entrance into the sea probably resulted in an early return as adults. Wild fish were smaller upon reaching the sea but stayed there longer before returning to the river.

Downstream trapping operations on the four major tributaries of the Alsea River resulted in a catch of 1,819 wild smolts, with most of the catch occurring in mid-May. Trap efficiency increased somewhat as water levels dropped, but it is quite likely that the 1956 smolt migration reached a peak during the first half of May. Other workers on the Pacific Coast have reported similar movement peaks.

At each trap location, smolts were given a tattoo which designated date and place of capture. Due to trapping difficulties, only one recovery was made. This was a smolt marked on the North Fork and recaptured in the lower river, 35 miles below the point of release. The mean rate of travel for this fish was six miles per 24-hour period.

After the smolt migration had ceased in mid-June, one downstream trap was left in position on the North Fork. No movement of smolts through this trap took place during the first fall freshets, which occurred in October.

Smolts were found to move in daylight hours as well as at night. For example, the trap on Fall Creek took 69 smolts from dusk on May 1 through 4 P.M. on May 2. At least 30 of these fish were known to have entered the trap between 9 A.M. and 4 P.M. on May 2.

A downstream movement of fish of the year was found to occur. These fry were about one inch in length and had the egg-sac newly absorbed. About 800 trout of this age were caught in the period from April 27 to June 21. All but seven were taken after May 28. Although some of these fish of the year could have been cutthroat trout (*Salmo c. clarki*), the timing of the movement peak and the small size of the 0/ fish suggest that most were newly hatched steelhead. These migrants may have moved downstream to find living room out of crowded tributaries or they may have continued out to sea. If the latter is the case, the absence of 0/ fish from adult scale samples indicates a low or nonexistent survival. Traps placed in the lower river in June failed to catch 0/ trout. This may lend credence to the theory that fish of the year move downstream only until a suitable niche is found. Of course, the traps could have been ineffective.

In order to obtain information regarding rate and times of downstream movement of hatchery-reared smolts, an experimental release of 7,900 fish was made on May 22, 1956, with 2,700 fish each released in the North and South forks and 2,500 in the lower river. Mean size of the smolts was about 6.25 inches (ten fish per pound). All smolts were marked with tattoos or latex injections to indicate location of release. The nature of the 670 recoveries indicated that some liberated smolts migrated immediately, while others remained in the streams, probably over the winter. Fish that did not migrate lost condition rapidly, and no growth was apparent on scales taken from these residual fish in September. Marginal absorption on some of the scales indicated that the fish might have been losing weight or merely holding their own. Six recoveries of marked smolts liberated in the North and South forks were made at a point about 35 miles below the release locations. The rate of travel for these six fish varied from 2 to 11.6 miles per 24-hour day.

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SUMMARY AND CONCLUSIONS

Aspects of the life history of the steelhead trout (*Salmo g. gairdneri*) of the Alsea River were investigated. Juvenile steelhead, or smolts, were trapped in 1956 on the main river and on four major tributaries. Fish were measured and tattooed, and scale samples were taken. Inclined-screen traps were used successfully. Adult steelhead scale samples procured during the winters from 1951 through 1955 were secured from anglers, commercial fishermen, and from a trap operated by the Oregon State Game Commission.

Analysis of 978 scale samples from wild adult fish revealed that over 90 per cent remained in fresh water as juveniles for at least two winters. About 52 per cent of all wild fish in the sample had spent two winters in fresh water and were returning to the stream to spawn after two summers of ocean life. The proportion of repeat spawners among 1,221 wild fish and steelhead of hatchery origin varied by year from about 3 to 17 per cent. Adults of hatchery origin probably constituted less than 10 per cent of the runs in the mainstem Alsea River from 1951 through 1955. The proportion of these fish in a sample of the 1955 adult run decreased as the winter progressed. This decrease was also true of the proportion of males in the run.

Analysis of 400 smolt scale samples indicated that 86 per cent had spent two winters in tributaries, 13 per cent had spent three winters, and 1 per cent had spent only one winter. Adults that had entered the sea at a large smolt size appeared to return at an earlier age to the stream than did adults that had first entered the sea at a small smolt size.

Scales from fish of hatchery origin demonstrated characteristics in the pattern of fresh-water growth that made it possible to separate wild from hatchery fish on the basis of scale analysis alone. Some hatchery-reared juveniles remained in fresh water over the winter following liberation. About 33 per cent of 243 adults of hatchery origin had spent a winter in the stream after liberation.

Rate of downstream movement of wild and hatchery-released smolts appeared to be relatively rapid. It also appeared that smolts spent less than six weeks in tributaries, in the main river, and in Alsea Bay after formation of the final fresh-water annulus. The downstream migration in 1956 probably reached a peak in mid-May. Smolts were found to move downstream in daylight hours as well as at night.

A downstream movement of fish of the year occurred in tributaries. Since none of the adult scales examined showed less than one fresh-water annulus, these fish of the year may remain in the lower river for one or more winters before moving to the sea. It is also possible that they move into the sea immediately and do not survive to adulthood.

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IDENTIFYING PROGENY FROM PHEASANT HENS GIVEN RADIOACTIVE CALCIUM (Ca^{45})

R. A. McCabe and G. A. LePage

Department of Forestry and Wildlife Management and Department of Oncology, University of Wisconsin, Madison 6, Wisconsin

Pheasant-stocking programs carried out by state conservation departments have come under criticism in recent years (Allen, 1953; MacMullan, 1954). Facts on which to base evaluation are, in most cases, decidedly limited. Limitation is often the result of an inability to measure all facets of the program.

The object of this study was to evaluate the use of an isotope of calcium (Ca^{45}) to identify the progeny of spring-stocked hens. Originally, we hoped to be able to check fall-stocked hens as well, but the half-life of Ca^{45} (163 days) was too short.

The contribution that the cock pheasant (*Phasianus colchicus*) makes to the stocking program has been investigated by the Wisconsin Conservation Department (Kabat, *et al.*, 1955; Besadny, 1956). No complete evaluation has yet been made of the contribution of the hens in the same program. About as many hens as cocks are released, generally in the fall. In the cock-evaluation program, pheasant legs and wings from study counties were sent to the Conservation Department by hunters (postage free) in self-addressed envelopes furnished by the department. Any method of evaluating the contribution of the released hen to the hunting bag must be geared for economy's sake to the same type of leg and wing collections as used for the stocked cock.

The use of isotopes in the field of wildlife management is relatively new, despite the fact that many researchers have realized its potential. In the early period of availability, radioactive tracers were too expensive and too dangerous to researcher and test animal for most wildlife problems. Recently, however, costs have been cut, and new long-half-life isotopes with soft (Beta) radiation have become available. Among these is calcium^{45}. Soft radiation implies low energy and low penetration. Thus, hard radiation (Gamma) with high energy can penetrate the skin of an animal and damage underlying tissue. Soft radiation, on the other hand, will not penetrate the outer layers of the skin and can therefore be handled safely without protective shielding. The low energy can at the same time be detected in very small quantities.

Calcium^{45} seemed best suited to this problem because it was relatively inexpensive ($5.00 per millicurie) and the tracer is deposited in the bones. When pheasant leg bones are available, those with radioactivity can be identified.

Before a research plan to use calcium^{45} in the field can be put into operation, there must first be established: (a) which compound of the isotope best suits the data-collecting method; (b) whether the isotope will travel from adult to young in detectable amounts; (c) if there is any adverse effect on the breeding physiology of the hen pheasant; (d) whether the half-life of the isotope is long enough to make a large-scale test practicable; and (e) that the isotope is in no manner harmful to humans.

PRELIMINARY EXPERIMENTS

Using chickens as test animals, a number of writers have shown a transfer of Ca^{45} from hen to chick (Driggers, *et al.*, 1951; Driggers and Comar, 1949; Spinks, *et al.*, 1949). That this transfer could be achieved in the pheasant, although likely, had to be confirmed. On June 30, 1955, we injected intraperitoneally each of 10 laying hen pheasants with 50 mcc. (microcuries) and each of 10 hen pheasants with 100 mcc. of calcium sulfate ($CaSO_4$) which contained Ca^{45}. Unfortunately, it was late in the laying period; however, we obtained 50 eggs from 19 hens. These were taken to the University of Wisconsin Poultry Department, where they were incubated in mechanical incubators. Only 12 young hatched from two settings. The text table below shows the fertility and hatchability data:

No. Eggs.	Infertile	Embryonic Death	Hatched
50	30 (60%)	8 (16%)	12 (24%)

How much of the infertility can be attributed to the isotope could not be determined; undoubtedly most of it was due to the lateness of season, at which time infertility or early embryonic death is known to rise sharply (records of the Wisconsin State Experimental Game and Fur Farm, Bert A. Barger, Asst. Supervisor, *in litt.*).

Eight egg shells taken at random from eggs laid by hens given the 50-mcc. dose level were examined for radioactivity. We used an end-window flow counter and the counts converted to counts per gram $CaCO_3$ per shell. The counts were also corrected for a time decay. They ranged from 951,000 to 11,000,000. The latter represent about 20 per cent of the injected dose (50 mcc. approximate 55,000,000 cts./min. on our counters). All shells showed considerable radioactivity, even when placed under an ordinary scanner tube, which is much less sensitive than an end-window flow counter. Of the embryonic deaths, three occurred between 14 and 16 days, three between 6 and 8 days, and two between 2 and 4 days. Two of the hatched young had splayed feet and died during the first week; four of the normal chicks also died during the first week. Six birds, three cocks and three hens, were raised to maturity.

The 1955 hatching peak for Wisconsin pheasants occurred during the second week of June (Frederic H. Wagner, pers. comm.). In order to simulate field conditions, the six surviving experimental birds and six controls (received from the state game farm at Poynette) were held until November 23 and November 30, when four of the controls and four experimental birds were sacrificed. This arrangement allowed the same time to lapse as that for wild birds hatched at the peak of the breeding season and shot in the first and second weeks of the hunting season.

When the birds were killed, a tarsus and foot of each were removed. A section of each tarsus was dried and dissolved in one molar HCl. The calcium was precipitated as carbonate and was put on aluminum counter plates. The amount per plate ranged from 5 to 10 mg. These were then run through an end-window flow counter.

The first two experimental birds ranged from 15 to 20 times the background count. There was no mistaking the progeny from the injected hens.

From each of these birds 1 gram of breast muscle was also taken and wet-ashed to oxidize all organic matter. To each sample, 2 mg. of Ca was added. Plates were again made and run through the counter. The count per minute for the injected birds was 20.4 and 22.1, respectively. Since the background count was 18/min., these results on the injected birds indicated extremely little

radioactivity and none that would be in any way harmful to anyone eating the bird.

The second two experimental birds, killed on November 30, showed no difference in count per five-minute period from a pair of control birds of the same age when the tarsi of both pairs were checked with the scanner tube. There was, however, a highly significant difference in radioactivity when $CaCO_3$ plates were made.

The five chicks that had died in July and had been refrigerated for three and one-half months were placed under the scanner tube. Only two had a significantly higher count than the background of 23–26/min. One showed a very high count of 330/min., similar in magnitude to that found in one of the egg shells. This is not surprising, however, in the light of experiments with chickens (Spinks, *et al., op. cit.*) where most of the Ca^{45} fed in the mash was absorbed by the first and second eggs laid following a single dose of the isotope.

It was obvious that detectable amounts of the radioactive material would travel from the pheasant hen to the chick and persist from hatching to the hunting season. The major problem in this regard is that an intraperitoneal injection results in a rapid uptake of calcium, so that most of the calcium is deposited in the first half-dozen eggs laid after injection. This apparently parallels the results obtained from feeding Ca^{45} in the diets of domestic chickens (Spinks, *et al., ibid.*). Our limited experience here indicated that a dosing procedure must be worked out whereby the Ca^{45} given at one time is released slowly enough to cover the entire laying period. One possible method would be to put the Ca^{45} into pellet form as a slightly soluble salt. Such a pellet under the skin or in the peritoneal cavity should put the material in a place where it is easily picked up but released slowly.

PELLET IMPLANTS

To test the hypothesis that a pellet implant would allow for a longer uptake period and a more evenly distributed dose, a number of pellets of calcium sulfate ($CaSO_4$) were made using Ca^{45}. The pellets, about half the size of an aspirin tablet, were made with a small hand-operated pellet press, and each contained 50 mcc. of the isotope (Fig. 1).

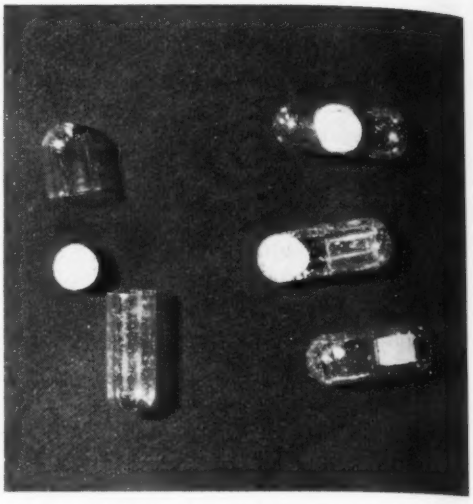

FIG. 1. Pellet and capsule used to implant female pheasants and domestic hens with a calcium isotope.

On May 24, 1956, each of six laying pheasant hens was given a pellet subcutaneously. Three of the birds were implanted on the breast and three on the side of the neck, the latter site being highly vascular. It was somewhat difficult to implant the dry pellet into a relatively small incision because the pellet picked up moisture readily and would not easily slide into position. Surgical clamps closed the incision. Similar implantation sites on domestic hens are shown in Fig. 2.

On June 16, 1956, another six hens were similarly given the radioactive calcium compound. These implants were greatly facilitated by putting the pellet in a gelatin capsule. A small incision and an inch-deep corridor probed under the skin with a pair of tweezers, allowed the capsule to be slid into place with the fingers. We closed the opening with two sutures.

All hens were housed three to a pen with a cock pheasant. Eggs were gathered daily and on June 12, 67 eggs were put into an incubator. From these eggs, 47 chicks were hatched. A second setting of 122 eggs on June 26 produced only 51 chicks. All chicks

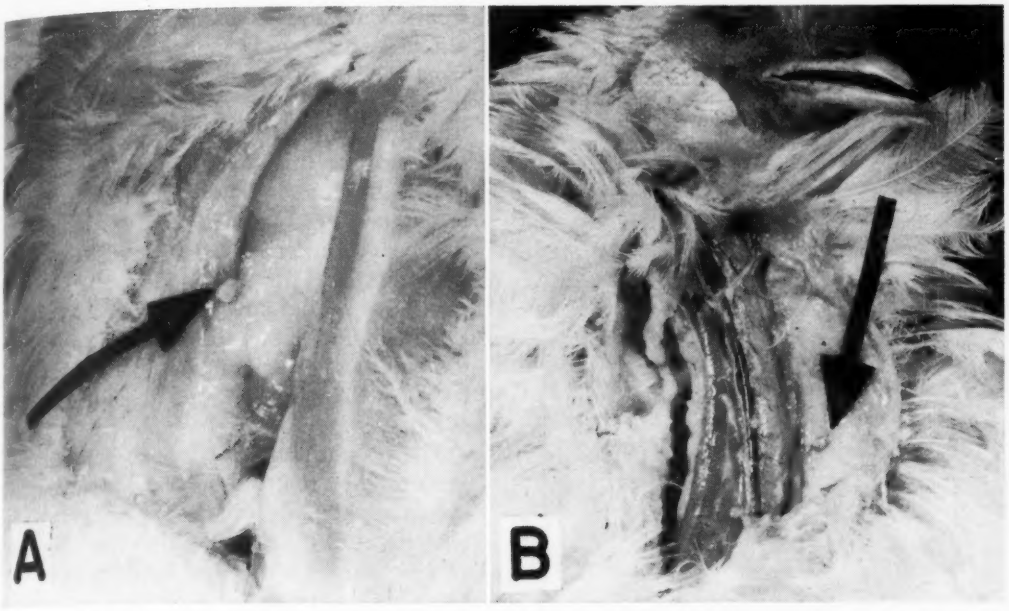

FIG. 2. Pellet implanted subcutaneously (A) on the breast of a leghorn hen, and (B) on the neck. Photo taken 48 days after implanting.

were wing clipped and later leg banded. Thus a record from the egg to adult pheasant was kept intact by means of this marking system. The birds were reared at the State Experimental Game and Fur Farm. They were held until November 7, a time span equal to that required to rear a wild bird from the peak of summer hatching to its death during the first week of the Wisconsin shooting season. After a sample of 41 birds was sacrificed, a leg bone from each was processed by the same method used the previous year. These data are plotted (Fig. 3) in such a way that the amount of radioactivity could be correlated with the length of time between implantation and the laying of the egg which produced the bird being tested. Labeling fell away rapidly, even when the calcium pellet was implanted subcutaneously, although less so than in the intraperitoneally injected birds. It appeared that even the $CaSO_4$ pellet was too soluble to allow for a protracted period of calcium uptake.

At the time pheasant leg bones were being analyzed, four laying leghorn hens were given $CaSO_4$ pellets to check on the radioactive calcium present in the egg shells. After three and one-half months a sample of accumulated eggs was plated and examined. The rate of radioactivity loss was rapid and similar to that found in the pheasant leg bones processed earlier (Fig. 4).

New pellets were made using a less soluble compound, $Ca_3(PO_4)_2$. To test this compound on pheasants would have required another breeding season. Since the amount

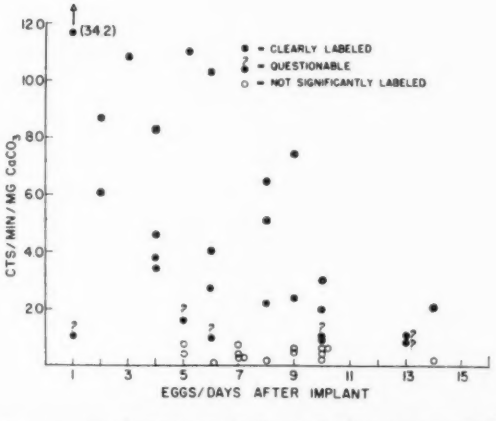

FIG. 3. Radioactivity in legs of pheasants reared from eggs laid by a pellet-implanted hen.

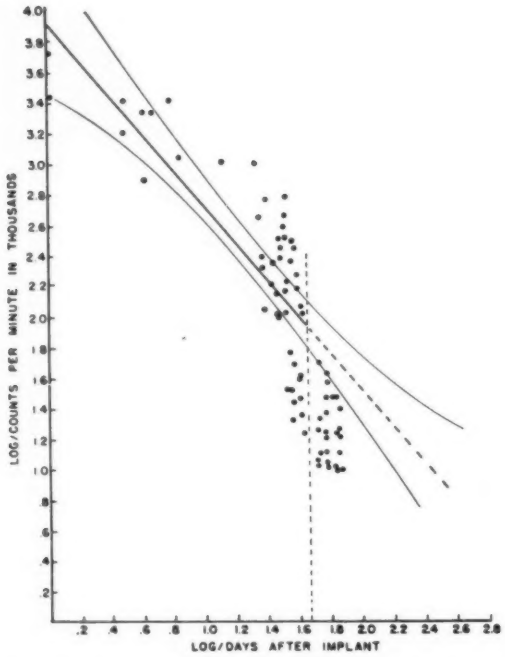

FIG. 4. Loss in radioactivity found in the egg shells of leghorn hens implanted with $CaSO_4$ pellets containing Ca^{45}. ($y = 3.903 - 1.1796x$.)

of radioactive calcium uptake by embryos appeared to be directly proportional to the amount available in the egg shell, the new pellets were given to two pairs of leghorn hens. In the pair that produced best, one hen was given a 37-mcc. pellet and the other 74 mcc. of the calcium compound. Eggs were again collected for a period of 40 days and the amount of radioactivity determined. These data are plotted separately for each hen in Fig. 5. Although the levels of the two curves are not the same because of a difference in dosage, the slopes are similar and show a much-reduced rate of loss in radioactivity. This compound ($Ca_3(PO_4)_2$) appears to be adequate for field use.

CALCIUM CARRY-OVER

It was shown above that there was no radioactivity in the breast-muscle tissue of the fall-sacrificed pheasants reared from eggs laid by intraperitoneally injected hens. Six birds of the same age reared from eggs laid by implanted hens were similarly treated and again showed no radioactivity above background. These were pheasants from eggs laid from one to 28 days after implantation. There appears to be no danger to humans in eating pheasants from an experiment of this kind, since the levels of the isotope used did not carry over in amounts detectable in the birds' muscle tissue. The amounts detectable in leg bones are significant for detection by the sensitive counters used, but were not significant from the health standpoint (e.g., estimated amount per lower leg bone of highest level found = 0.01 mcc. Ca^{45}). (Needless to say, the bones are not used for food.)

We thought that the bones of implanted hens might act as a reservoir for radioactive calcium which, during the subsequent laying season, could be marshaled for egg-shell production. Two adult pheasant hens that were implanted on June 16, 1956 were sacrificed on March 26, 1957 (284 days). Their leg bones were analyzed in the same manner as described for the young birds and no significant amount of radioactivity was detected.

Another check was made on eggs laid by adult breeders in the second spring following implantation with $CaSO_4$. Ten eggs laid during the first week of egg laying were examined, and no egg showed radioactivity significantly above the background count.

Lastly, implanted pellets recovered at the time birds were killed were analyzed for activity. Five pellets from pheasant hens

TABLE 1.—RADIOACTIVITY IN RECOVERED PELLETS

	Compound	No. Eggs Laid	Cts./Min.	Pellet Age (Days)	Per Cent Calcium Remaining
Pheasant	$CaSO_4$	0	423,000	5	0.8
Pheasant	$CaSO_4$	59	36,000	129	<.1
Pheasant	$CaSO_4$	44	86,000	129	<.1
Pheasant	$CaSO_4$	35	25,000	129	<.1
Pheasant	$CaSO_4$	59	63,000	129	<.1
Leghorn 1	$Ca_3(PO_4)_2$	23	5,360,000	48	13.1[1]
Leghorn 2	$Ca_3(PO_4)_2$	29	5,830,000	48	7.0
Leghorn 3	$Ca_3(PO_4)_2$	12	3,390,000	48	8.3

[1] Dose double that of Leghorn 2.

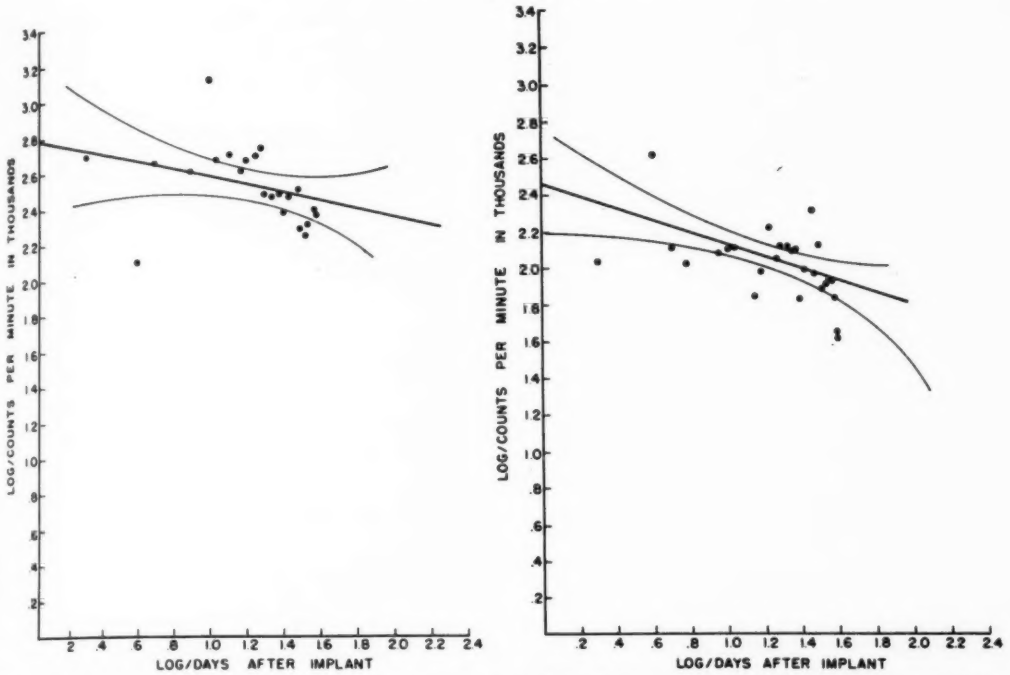

FIG. 5. Loss of radioactivity in the egg shells of two leghorn hens with pellets of $Ca_3(PO_4)_2$ containing Ca^{45}. In the test on the left, $y = 2.7967 - 0.2499x$; in the test on the right, $y = 2.4557 - 0.3438x$.

and three from leghorn hens were examined (Table 1). The calcium sulfate ($CaSO_4$) pellet showed only a small fraction of 1 per cent activity after 129 days. Moreover, the loss was very rapid. In one case, where the pellet was recovered after five days, only 0.8 per cent of the active dose remained. The calcium phosphate implants in leghorn hens showed 13.1 and 7 per cent of the active dose remaining after 48 days, from pellets of 74 and 37 mcc., respectively. Both hens (1 and 2, Table 1) began to lay immediately after implanting and at a similar rate throughout the test period.

It appears that the number of eggs laid does not greatly affect the loss of radioactivity. The relatively rapid decay rate and loss through excretion mask the minor reduction in radioactivity through calcium loss in egg production.

Thus, no carry-over of radioactivity was found in the breast muscle of young pheasants reared from radioactive eggs, or in the leg bones of adult hens that had carried radioactive pellets, and only a small percentage of the total dose remained in some pellets recovered 50 days after implantation. In this experiment the only difference in the two compounds used ($CaSO_4$ and $Ca_3(PO_4)_2$) was in their solubility. The amount of contamination or carry-over would be similar inasmuch as the compounds act only as carriers for Ca^{45}.

DISCUSSION

Radioactive calcium can be used for tracing the progeny of hen pheasants stocked in the spring. It is not expensive, and is relatively easy to administer and to recover. A half-life of only 163 days is its only limiting aspect. Calcium^{45} is an adequate tracer, when passed from hen to egg to chick, and can be detected from the peak of hatching in June to the end of the hunting season in late October. Labeled hens from properly timed spring releases would very likely produce labeled progeny that could be detected in the fall hunting bag. This detection is possible if there is no great delay in the onset of egg laying after release. We found that

two leghorn hens were producing eggs of significantly high counts, 38 and 39 days respectively, after pellet implantation. It seems likely that a spring-stocked pheasant hen will begin nesting two to three weeks after release. The pellet, we believe, will be completely effective for at least one month after implantation. Our results indicate that hens labeled and released in fall would not retain sufficient radioactivity to label eggs in the following spring. It is entirely possible that an isotope with a longer half-life can be used or that a method of producing delayed action of Ca^{45} can be worked out to label fall-released hens.

Implantation is best accomplished by use of a pellet encased in a gelatinous capsule. Walling off of the pellet was neither accelerated nor retarded when a capsule was used. The rate of uptake may be influenced by the degree of walling off, but the fact that virtually all of the calcium was lost from the pellets indicated that connective tissue was no deterrent to labeling when a subcutaneous pellet was used.

The cost per bird to be checked will vary with the number involved and the skill of the laboratory technician, but at present such cost would not be prohibitive for an experiment of this kind involving as many as a thousand birds. This is particularly true if the results bear on policy relating to increased or decreased spending. A rough calculation of the cost to label and handle a thousand hen pheasants in all phases of an experiment would be about one dollar per bird. The above handling includes laboratory procedures in plating bone samples for determining the amount of radioactivity. It does not include the cost of obtaining pheasant leg bones. A short cut in the hen-egg-chick-adult sequence of labeling would be to set up a nesting study in which a percentage of nests found could be attributed to stocked hens. In our experience, presence or absence of radioactivity in an egg can often be determined by the use of a simple scanner tube and geiger counter. The eggs or egg shells could be examined at any time, even after the young have left the nest. The use of a scanner tube instead of the end-window flow counter would considerably reduce the cost of using the isotope.

From the standpoint of health hazards, our experiments show that offspring of pellet-implanted hen pheasants carry only a trace quantity of radioactivity in their bones during the first fall after hatching. This quantity is detectable only with highly sensitive counters. No significant radioactivity was found in the muscle tissue. Pellet-implanted hens carried over no radioactivity into a second breeding season.

The potential for using isotopes, as described here, to study predation is great. Future experiments might consider isotopes of boron or strontium.

ACKNOWLEDGMENTS

We wish to thank the staff at the Wisconsin Experimental Game and Fur Farm at Poynette, Wisconsin, for the co-operation extended us in the handling of eggs and rearing of pheasant chicks. Our thanks also go to H. R. Bird and W. H. McGibbon of the Department of Poultry at the University of Wisconsin for facilities for incubating pheasant eggs and for making available laying hens for test purposes. Others whose help is gratefully acknowledged contributed as follows: R. P. Breitenbach and E. E. Woehler aided in gathering pheasant eggs from game-farm breeders. A. E. Eynon handled the laying domestic hens. J. C. Neess gave advice on sampling procedures. Mrs. D. McManus and Mrs. M. Gilboe of the McArdle Laboratory, University of Wisconsin, made the radioactivity determinations. The Ca^{45} was obtained from Oak Ridge National Laboratories on allocation by the U.S. Atomic Energy Commission.

SUMMARY

Radioactive calcium (Ca^{45}) in several compounds was given to hen pheasants and to white leghorn hens to see if the isotope could be detected in egg shells or in the leg bones of the progeny of the treated birds. $CaSO_4$ was administered as a liquid intra-

peritoneally and as a pellet subcutaneously. The uptake and release of calcium was so great that use of this soluble salt was considered impracticable. A second, less soluble compound, $Ca_3(PO_4)_2$, appeared to be suitable, when implanted as a subcutaneous pellet, to release the isotope slowly over a period sufficient in length to allow a spring-released pheasant hen to lay a clutch of eggs containing a detectable amount of radioactivity.

Once an egg is significantly radioactive, this activity is transferred to the chick and is also detectable in the leg bones of the young adult in the fall.

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DEER NUMBERS, KILL, AND RECREATIONAL USE ON AN INTENSIVELY MANAGED FOREST[1]

Donald W. Burcalow and William H. Marshall

Minnesota Department of Conservation and University of Minnesota, St. Paul 1, Minnesota

Records of deer populations as related to habitat conditions and kill by hunters are essential to understanding the interplay between forest- and wildlife-management programs. This paper presents: (1) historical information on the development of a conflict between deer and forestry, in the years 1930 to 1945, when deer hunting was prohibited; (2) a series of data, for the period from 1946 through 1956, when this conflict was resolved; and (3) a discussion of hunting intensities and deer kills that appear to have been consistent with the production of wood products on an intensively managed forest area.

At the University of Minnesota Cloquet Experimental Forest, both authors have been able to conduct checks on hunters and on the white-tail deer (*Odocoileus virginianus*) killed during nine open hunting seasons from 1947 through 1956 (except 1950). It has also been possible to gather data on deer numbers and browse conditions each spring by organizing, on a project basis, a course in "Techniques of Forest Wildlife Management" conducted for senior forestry students by the junior author. Finally, through the good offices of T. Schantz-Hansen and Raymond Jensen, many details of forest management and history of the area were readily made available.

The Cloquet Experimental Forest at present encompasses about 3,300 acres in a nearly rectangular tract located about four miles southwest of the city of Cloquet, Carlton County, Minnesota. Sections 29, 30, 31, and 32 of T. 49N., R. 17W. and Section 36 of T. 49N., R. 18W. are now entirely in University of Minnesota ownership.

[1] Paper No. 3822, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

SOIL AND COVER TYPES

The soils found in the forest occur extensively in northeastern Minnesota. Nearly 56 per cent of the area is loamy sand (Omega and Sebeka types), about 34 per cent is peat, 9 per cent is sandy loam (Cloquet and Munger types), and there is a small acreage of alluvium. The lowland (peat) and upland areas (sandy soils) are will interspersed.

A description of the cover types found on the forest can best be summarized after Magnus (1949), who described 16 types for the 2,817.6 acres that were controlled by the University in 1948. These acreages, as presented below, have since changed somewhat, chiefly through clear cutting of mature stands in about 100 acres of jack pine (*Pinus Banksiana*) and 130 acres of aspen (*Populus tremuloides*) between 1948 and the summer of 1956. The additional acquisition of 500 acres since 1949 has not materially changed the relative amounts of cover types.

The largest single cover type consists of jack pine, which embraced 596 acres in 1948. Others, in descending order of acreage, were: upland conifer–hardwood—439 acres, lowland conifer–hardwood—283 acres, lowland conifers—260 acres, aspen—239 acres, mixed pines—190 acres, muskeg—144 acres, lowland brush—131 acres, red pine—112 acres, conifer slashings—106 acres, tamarack—77 acres, spruce–tamarack—74 acres, aspen–birch—71 acres, open—54 acres, upland brush—42 acres, and hardwood slashings—11 acres.

Cursory examination of a timber-type map of the tract clearly shows that there is a considerable intermixture of types. This map is based on standard land survey "forties," i.e. 16 units to the section or square mile which are termed compartments. Only one or two of the 40-acre compartments on the forest are covered by a single cover type. In a majority of these 80 compartments there are at least four types represented.

The timber stands in the area around the forest are largely second-growth aspen, with farms and recently abandoned farmlands making up the bulk of the boundary. About one-fourth of the land on the outside of the boundary line consisted of open fields in 1948 and about one-fourth was and still is swampy in character.

FIRE AND LOGGING HISTORY

Fire scars on mature red pine (*Pinus resinosa*) in the forest indicate that a large part of the area was repeatedly burned in the nineteenth century. Severe fires have been postulated for 1819, 1842, 1864, 1874, 1885, and 1894 (Hansen, *et al.*, 1936). Fire records at the forest headquarters, which date from 1910, show that the Cloquet fire of 1918, which swept over tremendous acreages in this region, burned only 19 acres in the southwest corner and about 40 acres in the northeast corner of the present forest. Between 1930 and 1939 only 8 acres in the forest were burned, while between 1939 and 1956 there have been five small fires. One of these covered 45 acres north and west of Otter Creek (at the time of the fire, this was not a part of the forest proper), and two covered 1/10 acre each. Two small areas (2.5 and 3.5 acres) were burned experimentally in early May 1952. Thus, there have been practically no fires on the forest tract since 1910.

Most of the forest area had been recently logged when the major part of the tract was acquired by the University in 1910. There are no records available on these operations. However, somewhat over one million board feet in certain pine stands were uncut. Much of this remains in three stands of virgin red pine that total 112 acres in area.

Between 1910 and 1939, there was a considerable amount of both partial and clear cutting. During the period from July 1, 1933 to June 30, 1937, personnel from a CCC camp at nearby Big Lake removed all dead and down timber within 50 feet of the roads and later extended this operation to the entire forest. Stand improvement and release cuttings were carried out by CCC camp crews on 1,315 acres. The crews also planted 620 acres with conifers on sites scattered throughout the area.

Since 1939, timber cuttings have been made in many relatively small areas (Fig.

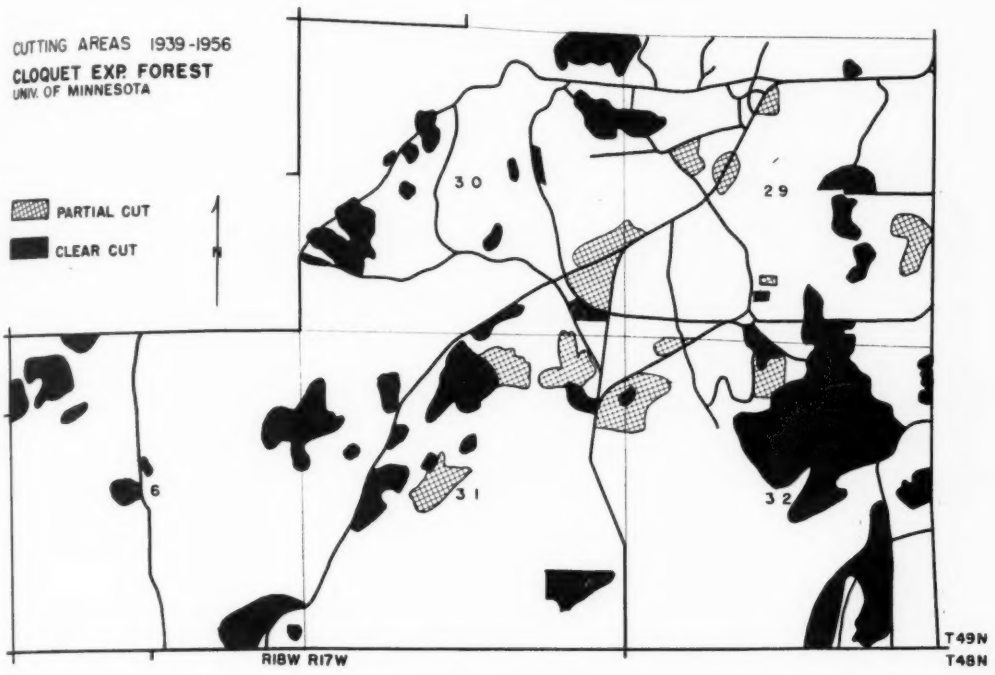

FIG. 1. Cutting areas, 1939–56, road system, and section lines.

1). Sixty-three separate clear cuttings have covered a total of 420 acres, and the average size of the area cut has been 6.5 acres. Most of these cuttings were in jack pine or aspen. Partial cuttings in ten stands of red pine and jack pine have covered a total of 66 acres, and thinnings have been made in 88 acres of red pine at eight different locations. The average size of these two latter types of operations has been about 8 acres.

The combination of the history of nearly complete exclusion of fires since 1910 and of many small timber cuttings under intensive forestry procedures since 1939 means that this area represents a nearly "ideal situation" from the forestry standpoint.

DEER-HERD HISTORY

Early records of the history of the deer herd in the forest are scant. Ralph T. King informed us that, when he began field work here in 1927, there were few, if any, deer present. The first bulletin on the forest, which was prepared in the early 1930's (Hansen, *et al., ibid.*), states: "Deer are not present in sufficient numbers to be a problem, or are they likely to become a pest on such a small area."

This situation changed in the next decade. Gustav A. Swanson wrote in the second report on the forest (Allison and Brown, 1946): "The population in 1944 is approaching a level which, if allowed to continue unchecked, is dangerous to plantations and to natural forest reproduction. . . . No deer line has yet developed, except in cedar swamps and in cedar in the arboretum." Swanson apparently thought the population was approaching "one deer per 25 acres," which would be about 25 deer per square mile at that time. He recommended deer hunting on a permit basis.

The junior author first became acquainted with the area in 1945. By that time, and during the next year, deterioration of the deer browse and injury to forest reproduction had increased considerably; it was clear that deer numbers should be reduced.

Conditions in the cedar (*Thuja occidentalis*) swamp in the south-central part of

the forest have been observed each spring since 1946. Between 25 and 70 browse-survey plots, using the Aldous method (Aldous, 1944), have been run here by senior forestry students on an instructional basis. For this reason these data must be accepted with reservation, but they can be used as a basis for general comment. The white cedar, red osier dogwood (*Cornus stolonifera*), and mountain maple (*Acer spicatum*) were noted as having low availability and heavy utilization in the first years of this survey. In recent years the availability of dogwood and maple has increased, and the degree of utilization dropped off considerably. However, although these species appear to be recovering, the cedar is not.

Another aspect of the deer-herd history is its relation to forestry practices in the area. In the period from 1945 to 1947, there was very heavy browsing on natural reproduction or plantations of white pine (*Pinus Strobus*) and jack pine in many of the small clear-cut areas. In the winter of 1946–47, Berklund (1947) studied in detail the conditions on two such areas which were regenerating chiefly to jack pine. He reported that about 90 per cent of the seedlings had been browsed and that, during that winter, 60 to 90 per cent of all the jack pine twigs were browsed. Equally heavy browsing on white pine occurred, although red pine was scarcely touched. It should be stated that, probably due both to deep snow conditions and to the first deer hunting season, this browsing did not continue in the next few years and that most of these pines have since developed into small saplings with no external signs of the old browsing.

Although the extent of browsing on jack pine and white pine shown by Berklund (*ibid.*) in the winter of 1946–47 was widespread over the forest at that time, by 1953 and 1954 this was not the case. In 1955 and 1956 it was possible to find heavy browsing only in a few strips about 100 yards wide along certain of the swamps. In general, however, browsing on coniferous reproduction has been negligible. Dr. Schantz-Hansen agrees with this conclusion.

Still another demonstration is available that deer browsing and injury to conifer reproduction have been practically eliminated. Since 1947, University forestry classes have installed 15 exclosures at intervals. These exclosures are 20 feet square, and one-half of each is deer and hare proof, while the other half is only deer proof. Nine are located in upland areas that had been clear cut during the previous winter. Three are in uncut open lowland conifer stands, and one is at the edge of the swamp. These latter four are where there had been heavy deer use in 1945 and 1946. Two others are in an area of swamp in which black spruce (*Picea mariana*) and cedar had been clear cut. Examination of these exclosures in the spring of 1956 showed little, if any, difference from the surrounding area as regards deer browsing.

Beginning in 1946, 12 censuses by the drive-census method (Trippensee, 1948) have been conducted on the western half of Section 36, as summarized in Table 1. This area is bounded on four sides by maintained roads and requires a minimum of 9 men stationed as counters. The drives have been run from north to south, with the number of men available for this varying between 20 and 70. When fewer than 20 men have been available, it has been possible to use the Morse method of tallying fresh tracks as described by Trippensee (*ibid.*). The coverage has been rated after each drive as indicated in the table.

These data show that the spring population has averaged about ten deer per square mile. The first three censuses, made while the area was still closed to deer hunting, indicate a slightly higher density.

In the authors' opinion, the western half of Section 36 is fairly well representative of the forest as a whole. On various occasions when snow was on the ground and when the 32 miles of compartment boundaries were covered during census activities for ruffed grouse (*Bonasa umbellus*), records have been kept of deer tracks encountered. These have indicated a widespread distribution of deer in the forest—a situation to be expected with the high degree of interspersion.

TABLE 1.—SUMMARY OF DEER-CENSUS AND KILL DATA, CLOQUET EXPERIMENTAL FOREST, 1946–56

Census on Western Half Sec. 36				Kill Data Entire Forest[1]				
Year	Date	Coverage	Deer/Sq. Mi.	Adults	Fawns	Unaged	Total	Kill/Sq. Mi.
1946	Jan. 13	fair	12+	Not open on forest				
1947[2]	Jan. 18	fair	8+					
1947	Apr. 11	good	14	6/3	1/1	2	13	2.6
1948	May 13	fair	8	0/2	1/1	–	4	0.8
1949[2]	Feb. 21	good	14					
1949	Apr. 27	excellent	6	4/1	2/1	–	8	1.6
1950	Apr. 27	excellent	12	No state-wide season				
1951	May 4	good	4	6/8	5/2	8	29	5.8
1952	May 1	fair	10	6/1	0/5	–	12	2.4
1953	Apr. 27	excellent	8	5/3	0/0	2	10	2.0
1954	May 3	fair	10	2/4	5/1	3	15	3.0
1955	May 2	poor	6	2/5	2/4	–	13	2.6
1956[3]	———	———	—	3/2	2/5	2	14	2.8
Total			112	34/29	18/20	17	118	
Average			9.3				13	2.6

[1] 5-day season 1947 and 1949, all others 9 days; data shown as males/females where sex was known to the authors.
[2] An additional winter census was made in 1947 and 1949.
[3] General cruising estimate on February 19, 1956 indicated 10–12 deer per square mile.

It must be stated that the degree of movement of deer into and out of the forest is not accurately known. In recent years there have been no heavily used deer trails crossing the boundary roads during the hunting season or in the late-winter periods. Reported heavy hunting pressure along the boundaries prior to 1947 may indicate that, when deer on the forest were protected, deer concentrated in the forest during the open seasons. However, there are numerous swamps with good cover in the vicinity of the forest, and extensive movement to this area appears unlikely.

Another aspect of the general deer-population situation concerns hunting pressures to the west and north of the forest. Much of this land is in an Indian reservation and receives a certain amount of year-round hunting.

HUNTING HISTORY

The Cloquet Experimental Forest was established as a game refuge in 1923. It was thought that exclusion of hunters would eliminate hazards to the facilities and/or personnel. There has undoubtedly always been a certain amount of poaching in the forest, but we believe that a similar intensity of illegal hunting occurred in the surrounding areas.

The forest has been opened to the hunting of deer of any sex or age with legal firearms each year since 1947, except 1950 when there was no state-wide season. All firearm seasons have been nine days, except for 1947 and 1949, which had 5-day seasons. In addition, in each year since 1945, bow and arrow hunting has been allowed on the forest during the entire month of October. However, no deer have been taken by archers.

Hunting pressure in the forest was quite uniform until 1955. During the first two years a permit system allowing 50 hunters for the season was attempted, but because of the many access roads this system proved to be difficult to handle and was abandoned. From 1949 through 1954, the daily numbers of hunters were estimated at close to 12 per square mile by counting parked cars and by the field checking of hunters interviewed in the forest. In 1955 and 1956, the average daily number of hunters dropped to eight per square mile, as nearby Jay Cooke State Park was opened to hunting and the easy targets there drew many people. This is considerably higher than the 1.9–5.9 hunters per square mile reported by Stenlund, *et al.* (1952) for the Gegoka Management Unit in the Superior National Forest from 1942 through 1949.

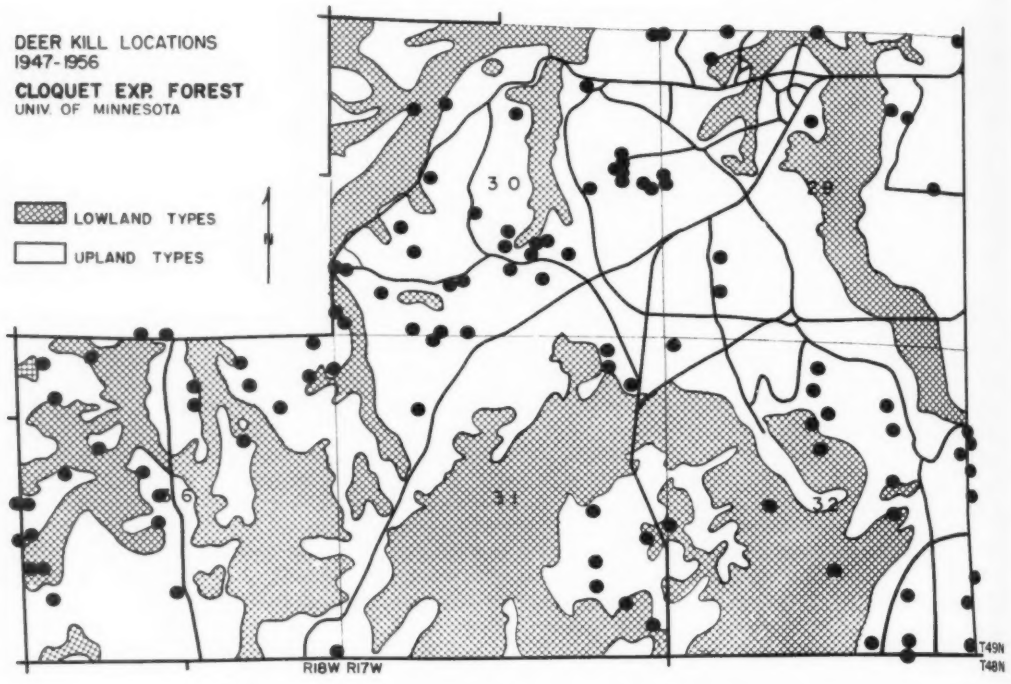

FIG. 2. Deer-kill locations, 1947–56, in comparison to major soil groups.

A majority of the hunters are local people —chiefly workers in the large industrial plants of nearby Cloquet. There is a good deal of half-day hunting all season, as the workers drive out between shifts. The forest is not only easily reached, but, due to the well-developed road system, almost all portions are readily accessible.

In spite of its accessibility, the area is considered a difficult one to hunt. There is a great deal of conifer reproduction, which provides excellent escape cover for the deer, and there are few well-developed deer runways. Many areas, particularly the jack pine stands, support very heavy growths of hazel (*Corylus americana*); this dense understory makes movement difficult for the hunter. Finally, the upland and lowland are so intermixed that the area is a difficult one in which to drive deer.

In fact, the hunters are reluctant to enter the dense lowland brush and coniferous types. This latter point is well demonstrated by superimposing the map showing the location of the kills known to be accurately plotted on one showing upland and lowland types (Fig. 2). When this is done, only three of the 115 kills plotted in the forest are found to be within the lowland types. Although many kills were made along the borders, the bulk of them were made in the upland areas.

THE DEER KILL

The recorded take of deer by hunters throughout the 9 years of open season has averaged 2.6 deer per square mile (Table 1). During this time, five deer that had been crippled and not recovered were reported.

Since the beginning of hunting in the forest, there have been excellent relations with nearly all of the hunters. Support from the local newspaper and sportsmen's club, as well as personal friendship of the authors with foremen in the plants, has made it possible to find out about the few deer killed on the forest that were not checked in at headquarters. Poaching losses are believed to be relatively small. When

all these items are considered, an average annual deer loss to the gun of three deer per section seems to be a reasonable estimate of the kill.

The known annual kill has been two or more deer per section, except for two years. These exceptions appeared to be related to snow conditions. In 1948, a heavy wet snow fell continuously during the opening day and the previous night. This markedly cut down on the visibility in conifer stands and made movement by the hunters particularly difficult, due to the bending over of hazel and alder (*Alnus incana*) stems. Since a cold snap followed the snowfall, this condition lasted throughout the season. In the next year, there was no snow present during the entire season. These two extremes of snow conditions are thought to have reduced the kill. In 1951 good tracking snows were present throughout the season and are believed to be responsible for the high kill that year. Similarly favorable conditions existed in both 1955 and in the first two days of the 1956 season. Probably this was responsible for maintenance of the rate of kill in spite of the marked reduction in hunting pressure. The estimated kill of 3 deer per square mile is comparable to that for a sample township in the Gegoka Unit from 1942 through 1946 where it varied from 1.8 to 6.3 (Stenlund, *et al., ibid.*). It is much higher than earlier and later kills reported in that area.

A summation of the kills by day of the season for the 8 years for which such data are comparable shows that 40 per cent of the deer were killed the first day and 26 per cent the second day. This is closely comparable to the Gegoka Unit data, as reported by Stenlund, *et al.* (*ibid.*).

The population structure of the deer shot on the forest is of interest when compared with other Minnesota data. Data for only 101 deer are, of course, scanty. The sex ratio of 63 adults was 117 males to 100 females—lower in males than that reported by Stenlund, *et al.* (*ibid.*) for the Gegoka Unit on the Superior National Forest and by Gunvalson, *et al.* (1952) for the state as a whole. The fawn/doe ratio based on 38 fawns and 29 does was 1.3 fawns per doe. This is slightly lower than the 1.4 fawn/doe ratio reported for the kill on the Mud Lake Refuge in northwestern Minnesota (Gunvalson, *et al., ibid.*), which was characterized as being an area with an expanding herd at that time; but it is much higher than the 0.6 fawn per doe reported by Stenlund, *et al.* (*op. cit.*) for the Gegoka Management Unit—an area of deteriorating range.

HUNTER USE

The use of the forest for hunting can be roughly estimated from data obtained in the field. For the period from 1947 through 1954, about 60 hunters per day used the area during the total of 55 days that were open to hunting (two 5-day and five 9-day seasons). In 1955 and 1956 about 40 hunters per day used the area during the 18 days open to hunting (two 9-day seasons). Thus, an estimated total of 3,900 hunting trips were made to the forest during the 9 years. When reduced to an annual square-mile basis, this total yields an estimate of about 90 trips per square mile for deer-hunting use of the forest each year.

These 90 hunting trips per year per square mile have yielded about 3 deer per square mile per year in "take home pay." The recreational value of these trips into the forest and/or of the trophies taken home cannot be estimated. With the exception of use by forestry students and loggers, the deer-hunting use of the forest has probably constituted the heaviest human use throughout the years involved.

DISCUSSION

The general values of these data lie in relating the history of the wildlife-management practices of refuge establishment and deer hunting to forest management. This relating should be done in light of the fact that, although most of the area was logged before 1910, it has been almost free from fire and has been the scene of many small clear cuttings since that time. In short, from several aspects, the Cloquet Experimental Forest represents what the foresters would desire to have much of this region

look like with continued highly successful fire control and intensive cutting.

Within this framework it appears that:

1) Complete protection from hunting first allowed the deer herd to develop from a very low level to an estimated 15 or more animals/square mile (spring count) during the period from 1930 to 1945.

2) This complete protection brought conditions of conflict between the deer herd and forest management in the form of damage to coniferous reproduction between 1940 and 1945. Also, by this period deer-browse conditions in the swamp types had deteriorated considerably.

3) Firearms hunting for 9 years between 1947 and 1956 has alleviated this conflict.

4) The hunting has provided some 90 hunting trips per year per square mile and has yielded about 3 deer per square mile on an annual basis.

5) This recreational use and alleviation of conflict with forestry interests has been based on the maintenance of a deer herd of ten animals per square mile on each May 1. Sex- and age-ratio data indicate a highly productive deer herd at this level.

SUMMARY

Descriptions and an historical record of the 3,300-acre Cloquet Experimental Forest in northeastern Minnesota are presented. In this area, which was established as a refuge in 1923, the deer herd built up from scarcity in the late 1920's to a density causing severe damage to forest reproduction and heavy browsing of the swamp areas by 1945. Since this time both the conflict between forestry interests and deer populations, and deer damage to the browse in swamps has been alleviated.

Between 1947 and 1956 nine open firearms seasons have permitted about 90 hunter trips per square mile per year and allowed an estimated annual kill of about 3 deer per square mile. Spring densities of deer have been estimated at about 10 per square mile. The data on age and sex ratios of 101 deer killed indicate a high production in the herd. Almost all deer have been taken in the upland areas and 66 per cent have been shot on the opening two days. In several instances the character and timing of the snowfall has appeared to affect the kill.

These data on forestry and wildlife conditions indicate that the hunting has resulted in a productive herd that is essentially in harmony with the forest-management program for the area.

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ECOLOGY OF THE CLAPPER RAIL IN SOUTHEASTERN NORTH CAROLINA[1]

David A. Adams and Thomas L. Quay

North Carolina State College, Raleigh, North Carolina

The clapper rail (*Rallus longirostris*) has been a game bird of some importance throughout the central and southern Atlantic Coast and Gulf Coast regions since the days of Audubon. The earlier information on this rail was assembled by Bent (1926). A first-hand natural-history account of the clapper rail at Cape May, N.J., was written by Witmer Stone (1937). Some aspects of nesting behavior and parental care were studied at Cobb Island, Va., in 1933 (Pettingill, 1938).

In more recent years several short-term investigations of habitat, nesting, behavior, populations, migration, and hunting have been accomplished, with a view to improved management, especially by: Kozicky and Schmidt (1949), and Schmidt and McLain (1951) in New Jersey; Stewart (1951, 1952, 1953, 1954) in Virginia; and Oney (1954) in Georgia. A similar investigation in California was done by Zucca (1954).

The present study was planned as a further contribution to the ecology of this still relatively little-known bird, with special reference to North Carolina. Five phases were considered: winter populations, nesting, trapping and banding of summer populations, fall migration, and hunting. The field research was conducted on week ends and holidays during the academic year 1955–56, full time during the summer (June, July, August, early September) of 1956, and on certain high-tide days in October and November of 1956.

The 3,400-acre salt marsh adjacent to Southport, N.C., was the principal study area. Tidal creeks divide the broad expanses of this flat, low marshland into numerous islands and peninsulas. Salt-marsh cord-grass (*Spartina alterniflora*) covers the muck soil in almost pure stand from the lower limit of vegetation to the higher, less frequently inundated ground, where it merges in places with *Juncus roemerianus*, *Spartina patens*, and *Distichlis spicata*. Along the edges of sand lumps or dredging spoils, it forms abrupt borders with *Iva frutescens*, *Borrichia frutescens*, and *Baccharis halimifolia*.

Methods and Procedures

The initial field work on the Southport plot, following some fall-hunting observations in the region, was on the size and behavior of the winter population. Study emphasis was on nesting activities during the spring months on 600 acres immediately facing Southport. Search for nests began in mid-March. Nests were found by searching methodically, on foot, the natural levee areas within the marsh. Calling locations of adult rails were helpful in finding individual nests. Subsequent trapping in the nesting area indicated that all nests present were not discovered.

Ten traps (Low, 1935; Stewart, 1951) were in use from June 11 to August 27 on the 600 acres where most of the nests were found. The trap consisted of chicken-wire leads and funnels, a heart, and a holding box or pound. The holding box was changed from a ramp type to a cone-on-ramp type, and pieces of stainless-steel leader wire were fastened to the sides of the funnels projecting into the heart; with these modifications very few birds escaped. In addition, flight-

[1] Based on a thesis presented by the senior author in partial fulfillment of the requirements for the degree of Master of Science, Division of Biological Sciences: Zoology, North Carolina State College, January 1957. Supported in part by funds from the North Carolina Wildlife Resources Commission, Pittman-Robertson Project No. W-44-R. R. J. Monroe and W. W. Hassler aided with statistical calculations.

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less birds were caught by hand or crab net during extreme high tides.

Yellow and red airplane dopes were used to mark the primaries of trapped adults. The dope was applied by brush and allowed to dry before the bird was released. These markings were clearly distinguishable on the birds in the marsh for at least five weeks.

Age and sex of collected specimens were determined by dissection. The tail was cut off just anterior to the oil gland, and the bursa, if present, was observed in place or found with little effort. The absence of a bursa was considered to be indicative of adulthood (Pettingill, 1956:321–322).

Hunting-kill data were secured through personal interview with hunters in the Southport and Beaufort areas.

WINTER POPULATIONS

Very few clapper rails were in the *Spartina alterniflora* marshes from late November to early April. These marshes were covered with tracks during the early-fall hunting season of 1955, but only a few tracks could be found in the following winter. Occasional calls were heard at sunset in good weather.

In the higher fringes of the marsh, however, more sign was found. This indicated that the remaining local population had left the lower marsh for the mixed community of *S. alterniflora* and *Juncus roemerianus*. Twelve specimens were collected here. Occasionally, some rails were found in the still more elevated, grass-shrub community of *Spartina patens, Iva,* and *Myrica*.

Attempts to develop simple and dependable winter-census methods were unsuccessful. Track counts on fixed transect lines were discarded because rail tracks still appeared fresh for as long as a month in the absence of extra-high tides or of rain at low tides. Calls were highly variable in time and number. The secretive habits of the rails precluded direct counts except during extreme high tides. Tides of the necessary magnitude are rare in the winter season.

Neither the wintering birds nor migrants apparently had yet returned in any numbers to the broader reaches of the pure *S. alterniflora* marsh by mid-April. On April 13 and 16, during a period of excessive tides, an effort was made to census completely two islands of about 300 acres combined. Not one clapper rail was recorded, although 23 sora rails (*Porzana carolina*) were counted. After the tide had receded on April 13, a single clapper rail was flushed from beneath a pile of drift bordering a sand lump. Several droppings and two feathers were found there.

NESTING

Time.—Thirty clapper rail nests were found, 26 of which contained eggs. The beginning of egg laying for first broods or first nesting attempts extended throughout April and May, with a strong peak during the last half of April (Table 1). The two nests begun in the first half of April were in the *Juncus roemerianus* marsh. Eight nests found on April 17 were partially built or newly finished and without eggs; these were in the mixed *Juncus–Spartina alterniflora* marsh. Nesting in pure stands of *S. alterniflora* did not start until immediately after the high tides of April 13–16. Search for new nests was discontinued in the second week of June.

TABLE 1.—INITIATION OF EGG LAYING, BASED ON DATE OF FIRST EGG IN NEW NESTS FOUND, BY WEEKS[1]

Week	Number of New Nests
April 1–7	1
April 8–14	1
April 15–21	9
April 22–28	8
April 29–May 5	4
May 6–12	0
May 13–19	1
May 20–26	1
May 27–June 2	1
9 weeks	26 nests

[1] Date of first egg determined by back-dating when necessary, allowing one day for each egg in nest at time of discovery.

Habitat.—Twenty-three of the 30 nests were in *S. alterniflora* growths of medium height (2–4 feet), 2 in short *S. alterniflora* (less than 2 feet), and five in *J. roemerianus*.

The use of medium growths of salt-marsh cord-grass for nesting sites was the same as in New Jersey (Kozicky and Schmidt, *op. cit.*; Schmidt and McLain, *op. cit.*), Virginia (Stewart, 1951), and Georgia (Oney, *op. cit.*). It would seem that nests were more easily found in these states than in North Carolina, presumably because of greater nesting densities and greater amounts of optimum habitat in the study areas there. Regardless of population density and geographic location, the preferred cover type of medium-high *S. alterniflora* everywhere on the Atlantic Coast furnishes the clapper rail with support and protection for its nest, a nest-site close to its creek-bank feeding areas, and high ground relatively protected from tidal inundation.

Clutch size.—The mean of 13 clutches known to be completed was 10.5±.29 eggs per clutch. The distribution was: 9 eggs—2 nests, 10 eggs—5 nests, 11 eggs—3 nests, 12 eggs—3 nests.

Oney (*ibid.*) reported an average clutch size in Georgia of 8.2 eggs per nest, with a range of 5–14 eggs, apparently based on about 100 nests in three years. Stewart (1951) found the average clutch size in Virginia (8.38±.18, range 5–11, based on 71 nests) to be "markedly less than in New Jersey" (9.97±.21, range 3–14, based on 104 nests). The 104 New Jersey nests were composed of 43 listed by Stone (*op. cit.*) for Cape May and 61 found in 1948 at Ocean City by Kozicky and Schmidt (*op. cit.*). Schmidt and McLain (*op. cit.*), in discussing the results of three successive years at the Ocean City study area, state that "the average number of eggs per clutch in 1948, 1949, and 1950 was 9.9, 10.00, and 9.3, respectively, based on 176 completed clutches." The North Carolina and New Jersey clutch sizes are statistically similar. The difference between the North Carolina and Virginia clutch sizes, however, is highly significant, as is that between Virginia and New Jersey. The complex subject of clutch size in birds, including the manifold intraspecific variations known to occur, has recently been reviewed by Lack (1954, 1956) and Davis (1955).

Chick development and parental care.—While one parent brooded newly hatched chicks and incubated any remaining eggs, the other sometimes led the first-hatched chicks as far as 50 feet away from the nest. This was particularly true if the birds were disturbed during the hatching period.

The chicks were brooded continually during their first few days, either on the original nest, on brood nests, or on patches of floating drift. The brood nests, constructed by the parents, were almost identical to the original nest but lacked a canopy; built of buoyant dead *Spartina alterniflora*, they floated with the rising tide and furnished dry places of refuge. As many as six newly made brood nests were found in the vicinity of a recently hatched brood.

The egg tooth was shed sometime after the fourth day. For the first three weeks the young showed mainly an increase in size; during this time they were able to swim and dive with ease for short periods. Continued immersion caused matting of the down and reduced buoyancy.

Newly hatched clapper rails peeped much like domestic chicks. They were capable of uttering shrill peeps audible about 200 yards downwind. When left exposed to the sun, or allowed to become chilled, their peeps changed to short squeals. These calls were retained through the sixth week. Some birds seven weeks old used both chick and adult call notes. By the time the young birds were fully feathered and flying, their calls were like those of adults.

The family group, as it fed through the marsh, was a loosely organized unit, often dispersed over an area 50 yards in diameter. Internal contact was maintained through the peeps of the chicks and the subdued clucks of the adults.

Sight observations and examination of two stomachs indicated that the food of newly hatched chicks resembled that of the adults (Oney, *op. cit.*). On three occasions adult rails were seen to catch fiddler crabs (*Uca* spp.) and break them into small pieces. Chicks, following single file behind the parent, would then run up and eat the fragments.

TABLE 2.—SUMMARY OF ALL RAILS CAPTURED AND BANDED

Method of Capture	Number Banded	No. of Repeats	Number of Mortalities	Total Captured
Wire trap	168	32[1]	15[2]	212
Clap net	3	0	0	3
Hand or crab net	24	5	0	29
Totals	195	37[1]	15[2]	244

[1] Includes 3 mortalities. [2] Includes 3 repeats.

The parental-care period extended into the fifth or sixth week after hatching. When chicks less than five weeks old were in traps, the parent birds were usually nearby. In two cases it was believed that the entire brood (10 and 7 chicks, respectively, aged 2–3 weeks) and both adults were captured. In no case of trapped chicks more than six weeks old was either parent believed to be in attendance.

The following index to the age of immature rails was developed on the basis of field observations and analysis of captured birds (Tables 2, 3). It agrees with the plumage and development descriptions by Bent (*op. cit.*), Oberholser (1937), and Schmidt and McLain (*op. cit.*), but gives more detail and is the first, to our knowledge, to show weekly changes and characteristics.

1–3 weeks: chicks all black, downy; bill white except at base, where it is black; toward the third week the black coloration extending throughout the basal half of the bill; legs light gray.

4 weeks: beginning of feather growth; first auricular tufts, then ventral and femoral tracts; bill black for about basal two-thirds.

5 weeks: appearance of feathers in all except capital, caudal, and alar tracts; bill becoming light gray, less distinctly black and white.

6 weeks: beginning of growth of capital, caudal, and alar feather tracts; iris becoming olive-drab.

7 weeks: primaries about one-half out of sheaths; continued growth of feathers; iris olive-drab.

8 weeks: primaries about three-fourths grown; bill and legs grayish.

9 weeks: sheaths still visible on basal one-half inch of primaries; legs beginning to show tinge of orange at "ankle"; bill becoming slightly orange at base; iris still olive-drab; flank markings indistinct; may or may not fly.

10 weeks: flying; no sheaths remaining; becoming more orange on bill and legs; flank barring becoming more distinct; iris becoming orange-brown.

10-plus weeks: becoming indistinguishable externally from adults; fleshy parts somewhat duller in color than those of adults.

Nesting success.—Eleven of the 26 nests (42 per cent) were successful. Ninety-nine

TABLE 3.—AGE COMPOSITION OF TRAPPED CLAPPER RAILS, BY WEEKS

Weeks	Juveniles: Small, Downy, 4 Weeks or Less[1]	Juveniles: Large, Feathered, 5–9 Weeks	Juveniles: Flying, Fully Developed, 10 Weeks or More	Adults	Totals
June 10–16	4	1	0	2	7
June 17–23	0	1	0	5	6
June 24–30	4	4	0	2	10
July 1–7	10	6	2	5	23
July 8–14	5	9	2	0	16
July 15–21	2	10	3	5	20
July 22–28	2	19	6	4	31
July 29–Aug. 4	10	16	10	10	46
Aug. 5–11	0	3	5	0	8
Aug. 12–18	0	12	2	2	16
Aug. 19–25	1	13	8	1	23
Aug. 26–Sept. 1	0	4	2	0	6
Totals	38	98	40	36	212

[1] Legs of chicks one week old too small for banding. Banding at 2–3 weeks of age done by trimming band slightly.

chicks were hatched in all, for averages of nine per successful nest and of 3.8 per nesting attempt. The 11 nests contained 18 unproductive eggs: ten were infertile, six were lost to natural causes prior to hatching time, and two died in pipping.

Two nests were destroyed by raccoons (*Procyon lotor*). In the remaining cases the cause of destruction seemed to be birds of unknown species, since the eggs were found pierced and left in or near the nests and no mammalian tracks were discovered. Tidal drift contributed to the loss of two nests by floating over the canopies and leaving the eggs exposed.

Nesting success in clapper rails, as reported by other investigators, is usually very high, often around 90 per cent, but occasionally drops below 50 per cent in the same area in any succeeding year. These figures invariably pertain to the initial nesting attempt. Several authors express the view that initial losses are usually followed by persistent renesting attempts, so that nearly every pair present finally produces at least one brood. The most common destroyer of first, and often succeeding, nests is widely recognized to be extreme high tides of both lunar and windstorm origin. These flood tides sweep over the nests and destroy eggs and downy young alike. The evidence in regard to recovery from such heavy nest loss, in the same or succeeding seasons, is not sufficiently well established. This subject, therefore, needs specific investigation before a more dependable population-dynamics formula can be developed. A continuing project was inaugurated in 1955 in New Jersey to study ". . . annual population trends . . ., initial nesting dates, and the effect of high tides on nesting success" (Ferrigno, 1957).

Brood cycle and nesting peaks.—The height of the beginning of egg laying at Southport in 1956 was about April 20–30. Allowing 11 days for the average clutch of 10½ eggs to be laid, the peak of the initiation of incubation was May 1–11. Allowing another 21 days for incubation placed the peak of hatching at May 22–June 1. After approximately five weeks of parental care, the main or first crop of birds of the year should have started independent life between late June and early July. Field observations and trapping results substantiated these calculations.

By comparing the heights of the hatching periods, nesting-season peaks for different geographic areas of the Atlantic Coast have the following gradient: Southport, N.C., 1956—May 22–June 1 (present study); Chincoteague, Va., 1950—June 1–10 (Stewart, 1951); Ocean City, N.J., 1948—June 16–21 (Kozicky and Schmidt, *op. cit.*).

TRAPPING AND BANDING OF SUMMER POPULATIONS

Two hundred and forty-four clapper rails were trapped or otherwise captured from April 29 to September 8, 1956 (Table 2). Most of these were trapped and banded between June 11 and August 27 (Table 3). The 32 trapped repeats were all retaken in the traps of their original capture.

The mean weekly catch per trap varied cyclically, apparently in some correlation with the high tides. The highest catches each month were in the week preceding the maximum high tides. Catches were low in the weeks of both the minimum and the maximum high tides. The lowest weekly catch of the summer came on the highest tide—August 5–11. These relationships may be explainable on the basis of the local habits of the rails in regard to range and movement.

As the date of the extreme high tides approached, the rails were increasingly disturbed each day, and more movement and higher trapping success resulted. By the time the maximum high tides had arrived, however, many of the birds had already left the stream-side areas in which the traps were located and moved to the higher marsh of mixed *Spartina alterniflora* and *Juncus roemerianus* or to the edges of sand lumps within the marsh, thereby becoming unavailable to the traps. As the tides receded, the rails returned to the low marsh, and the cycle began anew. This explanation was further supported by field observations in the hunting season.

FALL MIGRATION

At dusk on September 20, 1955, "hundreds" of clapper rails invaded Carolina Beach, N.C., preceding and during a heavy fog. The birds became confused and entered shops, flew into cars and people, perched on telephone wires and houses, etc. (John H. Farrell, pers. comm.).

During the early part of the 1955 hunting season (September), following hurricanes "Connie" (August 12) and "Diane" (August 17), very few rails could be found in the Southport marshes. Hurricane "Ione" came on September 19. By about October 1, however, the local population seemed to be almost "normal," according to general observations by Adams and reports of local hunters.

The following information concerning the fall migration of 1956 was obtained from Robert Halstead (pers. comm.), Federal Game Management Agent in Washington, N.C.: On October 1, Federal game agents collected 50–75 dead clapper rails beneath telephone wires in the Back Bay area of Virginia. Three days later, in the Bald Head Island marshes near Southport, N.C., Mr. Halstead observed the heaviest concentration of clapper rails that he had ever seen—25–30 at a time (high tide). They were very vociferous and definitely seemed to be in migration.

TABLE 4.—EIGHT BAND RECOVERIES (4 PER CENT), ALL RECEIVED FROM HUNTERS, SUMMER AND FALL OF 1956[1]

Date Banded	Age at Banding	Date of Kill	Elapsed Time (Days)
July 31	small juv.	Sept. 3	34
Aug. 27	large juv.	Sept. 5	9
Aug. 27	flying juv.	Sept. 21	25
July 7	large juv.	Sept. 22	77
July 15	large juv.	Oct. 4	81
Aug. 18	adult	Oct. 4	47
July 20	flying juv.	"hunting season"[2]	—
June 28	large juv.	Oct. 12 Valona, Ga.	106

[1] All banded at Southport, and all retaken there except the one in Georgia.

[2] Hunting season from September 1 to November 9.

The next day, October 5, Adams was in the same area. Although clapper rails were plentiful, no such concentration as Halstead had seen was present. The birds had apparently moved on in the one day.

If the Bald Head Island wave of October 4 was the same as passed through Back Bay on October 1, then the birds covered about 300 miles in three to four days. This seems to be a fast rate for rails, but banding and field observational evidence from Virginia (Stewart, 1954) suggest that "some rails travel rapidly from breeding to wintering grounds," and that "it is not improbable that most migrating rails would pass by this area [the extensive *Juncus* marshes of southeastern Virginia and North Carolina] without stopping, traveling directly from the Virginia 'Eastern Shore' to the Sea Island coastal strip of the southern Atlantic States."

Recovery reports of birds banded in Virginia have come predominantly from southeastern South Carolina, Georgia, and northeastern Florida (Stewart, *ibid.*). The eight recoveries of birds banded at Southport indicate that at least a portion of the breeding population there may be nonmigratory (Table 4). The Virginia subspecies is *crepitans*, that of Southport is believed to be *waynei* (Wetmore, 1941), and the Beaufort birds are thought to be intermediate between these two geographic races (Oberholser, *op. cit.*). Thus, observed variations in migratory tendency may involve subspecific differences. Of the 25 geographic races of *Rallus longirostris* (*ibid.*), only *crepitans* and *waynei* are migratory, with *waynei* supposedly less so than *crepitans* (*ibid.*; Ridgway and Friedmann, 1941).

AGE AND SEX RATIOS

The age composition of the trapped (summer, breeding) population is given in Table 3. The ratio of juveniles to adults was 4.9:1. Errors in separating flying birds of the year from adult rails should have been very few, and confined primarily to the last half of the summer. Such errors would have been in the direction of mistaking juveniles for adults, so that the juvenile–adult ratio would then be even higher. Of the 21 clapper rails

TABLE 5.—AGE COMPOSITION OF 205 CLAPPER RAILS KILLED AT BEAUFORT AND SOUTHPORT, 1955–56

Year	Month	Juvenile (Bursa Present)		Adult (No Bursa)
1955	October	28		3
	November	1		1
	December	6		3
Total		35		7
Ratio		5	:	1
1956	February	1		2
	September	72		10
	October	37		7
	November	29		5
Total		139		24
Ratio		5.8	:	1

captured on high tides, only one was adult. The presence of a few flying juveniles before the end of July indicated some successful local hatching before the late-May peak.

The results of aging 205 fall and winter specimens are summarized in Table 5. The nine birds of December 1955 and the three of February 1956 were the only ones taken outside of the September 1–November 9 hunting seasons. The juvenile–adult ratios of the two years were statistically similar to each other and to the summer ratio. There was severe habitat damage and high water in the three hurricanes of August and September 1955, but little or no storm damage in 1956. These data do not reveal any differential age mortality that might have accompanied or resulted from the storms.

TABLE 6.—SEX COMPOSITION OF 112 CLAPPER RAILS KILLED AT BEAUFORT AND SOUTHPORT, 1955–56

Year	Month	Male		Female
1955	October	23		8
	November	1		1
	December	6		3
Total		30		12
Ratio		71	:	29
1956	February	2		1
	September	22		21
	October	9		11
	November	2		2
Total		35		35
Ratio		50	:	50

Sex ratios of 112 clapper rails examined internally are shown in Table 6. The cause of the unequal sex ratio of the 1955 birds is not clear, since the majority of the specimens were immature. The October 1955 birds were collected at Beaufort, on the fifteenth day of the month. All other specimens were from Southport, many of which should have been migrants or winter residents. Larger and more directly comparable samples are needed.

CLAPPER RAIL HUNTING

Southport and Beaufort are the centers of clapper rail hunting in North Carolina. Some hunting-pressure and hunter-success data were obtained in the Southport area during the 1956 season (Table 7). It was not possible for us to be in Southport on all hunting days, nor to contact all hunters when we were there. The highest hunter success occurred on the days of highest tides —September 6, October 5, and November 3.

TABLE 7.—CLAPPER RAIL HUNTER SUCCESS, SOUTHPORT, 1956

Date	Hunters	Total Bag	Average Per Hunter[2]
Sept. 1	8	24	3.0
Sept. 3	12	36	3.0
Sept. 5	9	60	6.7
Sept. 6[1]	2	18	9.0
Sept. 7	1	5	5.0
Sept. 8	4	11	2.8
Oct. 5[1]	6	49	8.2
Nov. 3[1]	4	34	8.5
Totals	46	237	5.2

[1] Day of highest tide in the month.
[2] Daily bag limit of 10 birds per hunter.

During the high tide of September 6, Adams made an airplane flight from the southern border of North Carolina to Beaufort, an air distance of about 130 miles. The narrowness of the strip of huntable salt marsh allowed complete coverage in a single pass of about ninety minutes. Twenty hunters were observed, 18 in the Southport marshes and 2 at Beaufort.

All evidence indicates that the clapper

rail is not heavily hunted in North Carolina. In recent years, similar reports have been made for New Jersey (Schmidt and McLain, *op. cit.*), Virginia (Stewart, 1952), and Georgia (Oney, *op. cit.*). In earlier years the clapper rail was subjected to intensive hunting pressure, at least locally (Bent, *op. cit.*; Stone, *op. cit.*; Sprunt and Chamberlain, 1949).

SUMMARY

The breeding biology, seasonal populations, and behavior of the clapper rail were studied at Southport, N.C., in 1955–56. The wintering population was small, and confined primarily to the mixed grass and grass-shrub communities at the more elevated fringes of the marsh. Twenty-three of the 30 nests found were in *Spartina alterniflora* growths of medium height (2–4 feet). The mean number of eggs per clutch was 10.5± .29. Continuous parental care of the young lasted 5 or 6 weeks. Change from chick to adult call notes began at 7 weeks. The young started flying when 9 or 10 weeks old, by which time they were becoming indistinguishable externally from adults. A weekly index to the age of immature rails was developed and is described. Nesting success was 42 per cent, with an average production of nine chicks per successful nest. Local movements of the rails and trapping success were correlated with the rhythm and height of the tides. Fall migration of clapper rails through and from southeastern North Carolina apparently occurs in September and early October. Banding recoveries (4 per cent) suggest that part of the local population may be nonmigratory. The juvenile–adult ratios of the summer (trapped) and fall (shot) populations were approximately 5:1. The clapper rail is not heavily hunted in North Carolina.

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REPRODUCTIVE CHARACTERISTICS OF THE GRAY FOX IN SOUTHERN ILLINOIS

James N. Layne

Department of Biology, University of Florida, Gainesville, Florida

Although the general features of reproduction in the gray fox, *Urocyon cinereoargenteus,* are known, comparatively few detailed studies of its reproductive biology in different parts of its extensive geographic range have been made. Such investigations are not only important in regions where control or other management of foxes is necessary; they also significantly contribute to a more comprehensive knowledge of the over-all reproductive habits of the species and the variability of specific reproductive characteristics in different parts of the range and under diverse ecological conditions. The accumulation of such data is fundamental to a better understanding of the relationships of the physical and biotic factors of the environment to natality and other attributes of fox populations.

The present study is based upon a series of 218 gray foxes collected in Alexander, Jackson, Johnson, and Union counties in southern Illinois from December 1954, through June 1955. Of the total number of foxes handled, one was shot during the day, two were road kills, and the rest were killed at night after being lured within shotgun range with a call. The majority of the latter were obtained from cooperating hunters.

A few specimens were examined within several hours after death, but most of them were frozen as soon as possible after being collected and examined at a later time. When the condition of the carcass permitted, body weight and measurements were taken. Females were examined for the condition of the teats, vulva, and genital tract, the latter being preserved in 10 per cent Formalin for further study. When present, placental scars, uterine swellings, and fetuses were counted and their distribution in the uterine horns recorded. For the purpose of establishing approximate mating dates, the ages of fetuses weighing one gram or more were estimated to the nearest week by means of a growth curve of body weight established by Smith (1939) for the silver fox fetus. Although the chronology and details of embryonic development in *Urocyon* undoubtedly differ in some respects from *Vulpes,* the close phylogenetic relationship of the two genera, plus their general similarity in size and length of gestation, probably make this method of aging sufficiently accurate for the present purposes. The presence and relative development of follicles and corpora lutea in the ovaries were determined macroscopically by cutting sections of the gonads with a razor. Counts of mature follicles and well-defined corpora lutea were recorded separately for each ovary of a pair.

In the majority of the males handled, the weight and measurements of the left testis, minus the epididymis, were taken and a smear from a section of the right cauda epididymis examined microscopically for the presence or absence of spermatozoa. In a few cases microscopic checks for the presence of sperm were made from smears of epididymides that had been preserved in 10 per cent Formalin. This method appeared to be as reliable as examination of fresh smears. The relative size of the cauda epididymal tubules and the development of the prostate gland were also noted for each specimen.

Sex Ratios

On the basis of a total of 114 males and 104 females collected, an over-all sex ratio of 52 per cent males to 48 per cent females is calculated. This ratio does not depart significantly from a 50–50 ratio. The proportions of the sexes were nearly equal in all months except April and May (Table 1). The marked decrease of females in the samples for these months was correlated

TABLE 1.—SEXES OF 218 GRAY FOXES COLLECTED IN SOUTHERN ILLINOIS FROM DECEMBER 1954 THROUGH JUNE 1955

Month	Number of Males	Number of Females	Totals
December	12	11	23
January	26	26	52
February	21	17	38
March	19	20	39
April	16	7	23
May	7	4	11
June	13	19	32

with the period of late pregnancy, parturition, and early postnatal care of the young, suggesting that at such times vixens were less active or more secretive than usual, and were consequently taken with less frequency than their actual occurrence in the population. A further indication of this phenomenon may be the fact that, despite fairly uniform collecting effort throughout the reproductive season, no females in late stages of pregnancy were shot, and only one in a recent-partum condition was taken. The oldest fetuses recovered were estimated to be about 45 days of age. The return to a more nearly balanced sex ratio in June was probably associated with the termination of weaning and apparently signifies the resumption of normal activity by the adult vixens.

Twenty-eight fetuses sufficiently developed to be sexed externally consisted of 15 males and 13 females. Although the differences are not statistically significant in any case, it may be worthy of note that a similar tendency toward a greater number of male fetuses is indicated in data given by Sheldon (1949) and Layne and McKeon (1956).

AGE RATIO

All females taken from December through February could be classified as subadult or adult by the appearance of the reproductive organs and teats. The condition of the latter was particularly useful in aging individuals in which enlargement of the genital tract preparatory to breeding had begun, so that the marked differences between the sexually inactive, unbred animal and anestrous adult were no longer apparent. The teats of subadults showing no development of the tubal genitalia were about 1 mm. or 2 mm. in height and unpigmented. Yearlings near estrus or in very early pregnancy had nipples that had increased in size to about 3 mm. but still lacked pigment. The teats of adult vixens in the same stages of the sexual cycle were pigmented and measured from approximately 4 mm. to 6 mm. They were equally conspicuous during anestrum, being easily felt through the ventral pelage.

All males handled were sexually active, and no attempt was made to formulate criteria by which to differentiate the two age groups. Consequently, the proportions of yearlings and adults in the sample are based upon data for females only. Twenty-eight of a total of 54 vixens taken from December through February had not previously bred. Assuming that there is no significant sex difference in subadult mortality, these data indicate that young of the previous year comprised approximately 52 per cent of the breeding population. This figure is lower than that of 69 per cent immature animals in a sample of 156 females reported by Richards and Hine (1953) for Wisconsin gray foxes.

BREEDING SEASON

The reproductive condition of females during each month of the study is summarized in Table 2. Specimens in which

TABLE 2.—MONTHLY REPRODUCTIVE STATUS OF FEMALE GRAY FOXES

Month	Condition of Genital Tract					
	Not Enlarged	Semi-turgid	Fully Turgid	Pregnant	Recent Partum	Post Partum
Dec.	11	—	—	—	—	—
Jan.	17	4	3	—	—	—
Feb.	1	—	11	5	—	—
March	1	—	—	19	—	—
April	—	—	—	—	1	6
May	3	—	—	—	—	1
June	19	—	—	—	—	—

TABLE 3.—DISTRIBUTION OF 27 ESTIMATED MATING DATES

Month and Week	Number of Matings	Percentage of Total
January		
4	4	15
February		
1	5	19
2	7	26
3	8	30
4	3	11

the uterine horns had attained maximum enlargement and turgidity and the ovaries contained either mature follicles or recently formed corpora lutea were classed as "fully turgid." Although this category includes females ranging from a condition at or near estrus to one of very early pregnancy with implantation sites not yet discernible, the time interval represented is assumed to be short enough to permit the use of the dates involved as close approximations to the time of mating. In addition to these records were others provided by (a) back-dating to the nearest week of conception from a single reproductive tract showing characteristics of very recent parturition and (b) 12 litters in which the fetuses were large enough to be aged by the method noted above. A combination of all these records gave a total of 27 approximate mating dates. From the distribution of these dates (Table 3), it appears that the breeding season in southern Illinois extends from about the last week in January to the end of February, with a peak in mating activity during the middle of February. Whelping would thus be assumed to occur from March to May, with a peak in April. That this is not more strongly indicated in Table 2 by higher percentages of recent-partum specimens during these months is perhaps due to small samples in April and May and the further possibility that females having recently given birth may have been less susceptible to collection.

Marked activity of the mammary glands was first noted in females taken in March. These individuals, about 7 weeks pregnant, possessed a thick blanket of lacteal tissue, and the hair around the nipples showed incipient thinning. The teats of all post-partum vixens examined from April through June were much enlarged and heavily pigmented at the base. The fur on the venter was strongly tinged with reddish, and most of the hairs in the vicinity of the nipples had been shed. Lactating females were recorded from April through June. Eleven of 16 females examined during the first two weeks of June were still lactating, although only a slight amount of milk could ordinarily be expressed from the teats. It is probable that most litters in southern Illinois are weaned by the end of June, although lactation may continue until later in some vixens.

Hamilton (1943) has indicated that latitude is a factor in the breeding season in *Urocyon*. This relationship appears to be illustrated by specific data now available from New York, Wisconsin, and Alabama together with that obtained in the present study. Sheldon (*op. cit.*) and Layne and McKeon (*op. cit.*) found mating in New York gray foxes to extend from late January to May, with about 60 per cent of the calculated mating dates occurring in March. Richards and Hine (*op. cit.*) reported mating as taking place from mid-February to late March in Wisconsin. The height of breeding in Alabama occurs in February (Sullivan, 1956), which is in agreement with the data from southern Illinois. A difference of about a month in the mating season thus appears to exist between these more northern and southern localities in the eastern United States.

As is typical of many mammals, male gray foxes are sexually active over a longer period than the females. Sullivan (*ibid.*) presents evidence that male gray foxes in Alabama are fertile from November to April. The present findings are in essential agreement with this. All males examined from December through March had enlarged testes and contained sperm in the cauda epididymis (Fig. 1). Since collecting was not begun until December, no information is available on the earlier phases of the male reproductive cycle. Maximum testis weight was attained in January, slightly in advance of the peak in mating activity, with a steady

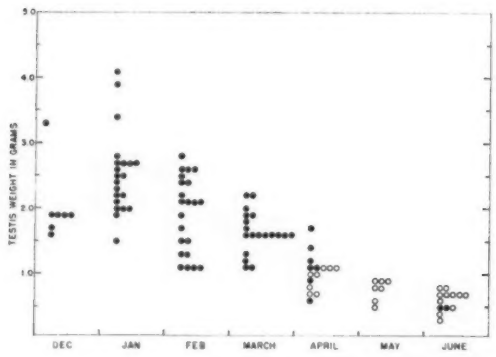

FIG. 1. Monthly testis weights. The solid circles indicate the presence of sperm in the cauda epididymis. Open circles denote the absence of sperm.

decline being evident during subsequent months. Eight of 15 males examined in April were infertile, as evidenced by the absence of sperm in the epididymis. The gonads were much reduced in May and June. Only two animals examined in the interval contained sperm in the epididymis, and in each case the gametes were so few as to indicate that the individuals were unquestionably reproductively inactive.

The size and appearance of the prostate gland were also useful in indicating the reproductive status of males and exhibited developmental trends more or less parallel to those of the gonads. When fully developed, the prostate is light in color and swollen, measuring in some instances as much as 12 mm. × 14 mm. in greatest length and breadth, respectively. In a regressed state the gland is dark and shrunken, measuring perhaps 9 mm. × 7 mm. and having a volume of only about one-seventh that of the active gland. With a single exception, all males in December had enlarged prostates. Two of 19 January specimens possessed undeveloped prostates, while in the remainder the glands were maximally enlarged. It is not clear whether the three individuals with small prostates in December and January represent adults that had only recently attained breeding condition and had prostates not yet redeveloped, or individuals that had already passed the peak of reproductive condition for the season and were entering the involutional phase. All February males had the prostate fully enlarged and swollen. In March, five specimens had well-developed glands. The prostate showed regressive tendencies in eight individuals and was completely reduced in six. The gland was still partially enlarged in one of nine April specimens and fully regressed in the others. It was small and dark in all males obtained in May and June.

The data suggest that males attain sexual maturity at an earlier age than do females. All males obtained during the early months of the study were fertile, while virgin females, presumably yearlings, occurred in samples from December through March. Three such specimens, showing no sign of sexual activity, were taken in December, 11 in January, one in February, and one in March. Other subadults in January, February, and March were in as advanced a stage of the reproductive cycle as adults taken at the same time. The lack of any nonovulatory females in samples from April and subsequent months may indicate that young of the previous year had all become sexually mature before the end of March. However, the possibility exists that some yearlings may reach puberty too late for successful mating or fail to produce young for other reasons. Such may be the case of a barren female taken in the middle of June. The reproductive tract and teats of this specimen were typically virginal, although well-developed corpora lutea were contained in the ovaries.

LITTER SIZE

Mean litter sizes, based on placental-scar and embryo counts, ranging from 3.66 to 4.5 have been reported for gray foxes in several regions (Gier, 1947; Sheldon, *op. cit.*; Richards and Hine, *op. cit.*; Layne and McKeon, *op. cit.*; Sullivan, *op. cit.*). In this study, combined counts of fresh placental scars in 32 females and uterine swellings or fetuses in 24 individuals gave an average litter size of 3.77±0.13 with a range of from 2 to 6 (Table 4). The difference between the separate means of placental scars and embryos is not statistically significant.

TABLE 4.—OVULATION RATE AND LITTER SIZE BASED ON COUNTS OF CORPORA LUTEA, PLACENTAL SCARS, UTERINE SWELLINGS, AND FETUSES

Item	Number of Counts	Mean	Standard Error	Range
Corpora lutea	66	4.41	0.12	3–7
Placental scars	32	3.62	0.15	2–5
Uterine swellings and fetuses	24	3.96	0.24	2–6

Although numbers of placental scars and embryos undoubtedly afford the best estimate of litter size generally available, both probably give values somewhat higher than the actual number of young that are born. This is due to failure to account for all losses due to resorption. Resorbed or resorbing individuals were easily recognized during later stages of gestation and were not included in the counts. However, it was not possible to distinguish between normal and abnormal implantation sites during early pregnancy, and, consequently, all visible swellings were counted in these cases. In view of the facts that the incidence of embryonic death may be higher during early stages and that a rather high number of early pregnant uteri were included in the sample studied, it seems likely that a significant number of resorptions were overlooked. Placental-scar data are liable to provide slightly biased estimates of actual natality through the inclusion in counts of sites at which resorption took place, but which are indistinguishable in postpartum uteri from sites representing normal pregnancies.

PRENATAL MORTALITY

The average number of ova produced per female, as indicated by the number of corpora lutea in the ovaries, was 4.41 (Table 4). Compared to a mean of 5.2 corpora lutea reported for gray foxes in both Ohio and New York (Gier, *op. cit.*; Layne and McKeon, *op. cit.*), the potential fecundity of the population under consideration appears to be significantly lower.

The significant difference ($P<0.05$) between the means for corpora lutea and combined placental-scar and embryo counts may be attributed to prenatal mortality. The extent of the latter can be calculated from the proportion of barren females in the breeding population, the percentage of ova or embryos lost prior to placental establishment in females becoming successfully pregnant, and the extent of resorption of fetuses from about 30 days to term. The estimate thus obtained appears to include all possible sources of ova and embryo loss throughout the greater extent of the gestation period.

A single barren female occurred in 49 specimens examined from March through June, a period when all other females that had ovulated were either in advanced pregnancy or contained prominent placental scars in the uterine horns. On this evidence a value of 2 per cent is obtained for the proportion of barren females in the breeding population. As mentioned previously, this specimen appeared to be a yearling. Percentages of barren females presented in other studies of the gray fox range from 3 to 6 (Sheldon, *op. cit.*; Layne and McKeon, *op. cit.*; Sullivan, *op. cit.*).

A total of 233 corpora lutea and 200 placental scars or embryos contained in a sample of 50 reproductive tracts indicates a loss of ova or embryos sometime prior to placentation of approximately 14 per cent. This assumes that the loss of embryos subsequent to this stage will leave persistent traces in the uterine horns. Dealing with a smaller sample of gray foxes from New York, the writer and W. H. McKeon (*op. cit.*) calculated mortality over the same interval to be approximately 22 per cent.

The frequency of resorption and the proportion of fetuses affected is based upon gravid uteri from March. Pregnant tracts obtained prior to this month were all in early stages, and it was not possible to recognize instances of resorption by gross examination. Of 19 gravid females examined in March, seven (37 per cent) contained resorbing fetuses. Fourteen (52 per cent) of the 27 fetuses carried by these animals had been affected. It should be noted that these percentages of incidence and extent of resorption, based on the latter part of gestation, cannot be presumed to apply

equally throughout the entire period of pregnancy, since there is evidence that mortality may be higher in earlier embryonic stages (Brambell, 1948).

Assuming a mean ovulation rate of 4.41, a proportion of barren females in the population of 2 per cent, a preplacentation loss of 14 per cent, and an incidence and extent of resorption of 37 and 52 per cent, respectively, a total prenatal mortality of 32 per cent is obtained. This figure exceeds that (approximately 15 per cent) calculated for Ohio gray fox populations by Gier (*op. cit.*), but is of the same order of magnitude as that (approximately 30 per cent) reported for New York gray foxes (Layne and McKeon, *op. cit.*). Although the estimate of over-all prenatal loss is essentially similar for the southern Illinois and New York populations, the values of the separate factors utilized in the calculation of this figure differ markedly in most cases. The relationship of such variability to genetic or environmental factors is of considerable practical and theoretical interest.

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SUMMARY

Reproductive data from 218 gray foxes taken in southern Illinois from December 1954 to June 1955 are presented and discussed. The over-all sex ratio of the foxes collected was 52 per cent males to 48 per cent females. A decline in the proportion of females in April and May was believed to be the result of reduced activity or tendency to respond to a call during the period of late pregnancy, whelping, and early postnatal care of the pups.

Based on the data for females only, yearlings comprised approximately 52 per cent of the population over the interval from December through February.

Twenty-seven estimated mating dates occurred from the last week in January to the end of February, whelping being assumed to occur from March through May. Lactating females were obtained in April, May, and June; weaning is probably completed in the majority of litters by the end of June. All males were fertile from December through March. About half of the animals were infertile in April, and all were reproductively inactive in May and June.

A mean litter size of 3.77 ± 0.13 (2–6) was obtained from counts of placental scars, uterine swellings, and fetuses. Actual mean litter size at birth is probably somewhat less because of the inclusion in counts of placental scars and early embryos of cases of unrecognized or potential resorption. A mean ovulation rate of 4.41, a proportion of barren females in the population of approximately 2 per cent, a preplacentation loss of 14 per cent, and an incidence and extent of resorption of 37 and 52 per cent, respectively, were obtained. Based on these values, a total prenatal mortality of approximately 32 per cent was calculated.

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THE FERAL BURRO IN THE UNITED STATES: DISTRIBUTION AND PROBLEMS

Tom L. McKnight

Department of Geography, University of California, Los Angeles 24, California

The principal purpose of this study is to bring together as much as is known about the present distribution of feral burros in the United States, with some estimates as to numbers, wherever possible. The secondary purpose is to describe the conflicts and competition with regard to land use that seem to accompany the burro, and to point out some of the effects of these problems.

Scattered in various portions of the western United States are several thousand feral burros, descendants of domestic burros that played important roles in the exploration and development of the arid and semiarid West. Although not native to this part of the world, these feral asses are remarkably adaptable, and have prospered in an adopted habitat that stretches from Mexico as far north as central Idaho. The burro is an exotic (i.e. nonnative), but is now well enough established in several western states as to be considered a permanent member of the fauna.

In spite of the fact that feral burros have been extant for many decades in the Southwest, and in spite of the fact that their presence generally has been recognized (Lummis, 1896), to a considerable extent they have been ignored in the varied literature of the region. Many of the inhabitants of the desert and semidesert portions of Arizona, California, Nevada, and New Mexico have strong feelings, either pro or con, about feral burros, for the burros aggravate land-use problems in these scantily vegetated areas. Yet, in spite of all this, only a relatively few individuals really know much about burros in the feral state, and there have been very few systematic attempts to study these interesting members of our contemporary fauna.

The writer is a geographer by profession, so the present paper is not written from the point of view of the zoologist or the ecologist. It is not a complete study, nor is it even exhaustive; it should be considered as exploratory and introductory.

BACKGROUND

The native habitat of the burro (*Equus asinus*) is northeastern Africa. It is commonly called the Somali or Nubian or Abyssinian wild ass, as those three areas comprise the core of its native range. It is the consensus of most authorities that the domesticated donkeys and burros of the world are all descended from the African wild ass (Simpson, 1951). Although wary and difficult to capture, *Equus asinus* was fairly easy to tame, so that domesticated asses are mentioned in very ancient historical records around the eastern end of the Mediterranean Sea. Records show that the ass was domesticated at least as early as 3400 B.C. in Egypt and Mesopotamia (Peake, 1933; Antonius, 1937). Being well suited to the dry subtropical environment, domesticated asses were widely used as beasts of burden, and to a certain extent as draft animals, through-

out North Africa, Mediterranean Europe, and southwestern Asia.

When Spain turned its attention toward the New World in the sixteenth century, the burro was imported to America. Burros had proved their worth as pack animals in Iberia, and they were to contribute extensively to the exploration and development of New Spain. Along with other forms of livestock, they were brought to America by early galleons. They were soon being bred and raised in considerable numbers in Mexico, and probably also in Hispaniola and other places.

Although used widely in other portions of the New World, these hardy and obstinate asses proved to be best suited to the drier lands of what is now northern Mexico and the southwestern United States. They were (and are) without peer as pack animals where the climate is dry, the terrain is rugged, the footing is unsure, and the vegetation is scanty. Prospectors, miners, and sheepherders found them particularly useful, and contributed toward their rapid dispersal.

The "feralization" process presumably began when burros first were set free. In some cases this must have amounted to "escape" from a loose confinement; in other instances the burros were deliberately turned out on the range and never rounded up (Weight and Weight, 1951). To these were added other burros that were left to shift for themselves after their owners had met with unexpected deaths. The freed animals apparently took readily to a feral existence (Ingles, 1954).

Except when forced to seek food or water or to escape persecution, it is conjectural whether or not feral burros wander widely from the localities where they or their ancestors were set free (of 13 southwestern naturalists queried on this point, 11 were of the opinion that burros do not wander extensively from their original areas of feralization). Even so, they became widely distributed over the Western States because of (1) being turned loose in so many different areas, and (2) their relatively rapid rate of reproduction. The feral animals generally retreated to the rougher and drier areas to escape the press of civilization.

Although domestic asses were first introduced into the American Southwest during the early years of Spanish exploration, the writer considers it unlikely that feral burros became widespread until sometime in the nineteenth century (Wyman, 1945). Burros were valuable chattel for several centuries, and if for some reason the whites did not want them, the Indians usually did. Therefore, unclaimed burros frequently were hunted down and captured. However, with the advent of better roads, improved means of transportation, and the fading of the mining boom, the importance of burros as pack or draft animals waned. This caused a speeding-up in the tempo of feralization. By the last quarter of the nineteenth century, large numbers of feral burros were being observed in various parts of the Southwest (Barnes, 1930).

DISTRIBUTION

Feral burros exist today in all of the Western States except Washington and Montana. The principal concentrations occur in California, Arizona, Nevada, and New Mexico, but they also are found in small numbers in Utah, Idaho, Colorado, Wyoming, Oregon, and Texas. This distribution is a reflection of their widespread use in domesticated pursuits. Table 1 shows the estimated numbers of feral burros, tabulated by state.

TABLE 1.—DISTRIBUTION OF FERAL BURROS BY STATES, 1957[1]

State	Estimate
California	2,000–5,500
Arizona	2,000–4,000
Nevada	700–1,500
New Mexico	500–900
Utah	50–150
Idaho	50–100
Colorado	50–100
Wyoming	25–75
Oregon	25–50
Texas	25–50
Total	5,500–13,000

[1] Based on mail-survey and field estimates by author.

The pattern of burro distribution is very uneven, as they are generally restricted to areas of rough terrain and inhospitable climate that are not in great demand for utilization as pasturage for domestic herds. In addition, a great deal of deliberate shooting and poisoning of wild burros has further limited their range and resulted in an even more spotty distribution pattern than might be expected.

Because of this uneven distribution pattern, the relative inaccessibility of much of the habitat, and the paucity of recorded observations, it is impossible to make a relatively exact census of feral burros in the United States. The burro has largely been ignored as a member of the fauna of this country, which means that counts or estimates of local populations rarely have been made. However, in spite of the obscurity of data, the writer has endeavored to gather as much information as possible concerning the distribution and numbers of feral burros in the West. The method employed involved an extensive mail survey, supplemented by field interviews and observations (McKnight, 1957). In spite of the handicaps inherent in such methodology, the results were satisfactory. The writer has been able to develop crude but seemingly sound estimates of the current distribution of these animals in the United States.

Of the ten states involved, only in California has there been a systematic effort by wildlife-management personnel to produce estimates of the burro population. Reports from other states were frequently vague and nonquantitative. However, in most instances there was sufficient overlap in reports from different sources as to permit a certain amount of checking. One major difficulty involved the sometimes-vague distinction between feral, semiferal, and nonferal burros. For purposes of this study, feral burros were considered to be those that were unbranded, not subject to an annual round-up, and apparently not within effective ownership control.

The major concentrations of burros (Fig. 1 and Appendix) occur in two generalized areas: (1) along the Colorado River from southern Utah to the Mexican border; and (2) in various desert mountain ranges of southeastern California. The former contains probably 45 per cent of the total wild burro population of the United States, and the latter, another 40 per cent.

California contains more burros than any other state, and they are nearly all in the southeastern portion. The most pronounced concentrations are in the mountains and hills surrounding Death Valley, Panamint Valley, and Saline Valley in Inyo County. However, the area between U.S. highways 91 and 66 in central and eastern San Bernardino County also contains burros in profusion. The remainder are scattered.

Burros in Arizona are mostly restricted to the western part of the state, although the eastern portion has a few. Major concentrations are found bordering the Colorado River along almost the entire length of its passage through the state. The highest density occurs in the Grand Canyon, although the mountains overlooking lakes Mead, Mohave, and Havasu are also densely occupied.

There have been concerted efforts in Nevada to remove burros from the range, with the result that only scattered bands remain. These are concentrated principally in the extreme southern part of the state, but a few burros are found in all but the northeastern portion of Nevada.

Although the burro population of New Mexico was once quite widespread, only a few remnants are extant today. These occur in scattered bands throughout the western half of the state.

Burros today occupy a much less extensive range than was true a few decades, or even a few years, ago. Large areas in most parts of Arizona, New Mexico, and Nevada, and in portions of southeastern California, Utah, western Colorado, western Texas, southern Idaho, southeastern Oregon, and southern Wyoming, once had significant burro populations, but no longer do. This is discussed below in greater detail.

The habitat occupied by feral burros, although characterized by rough terrain,

(Continued on page 168)

APPENDIX TO FIGURE 1

The Principal Areas Where Feral Burros Are Found in the United States, 1957
(Listed in parentheses are the principal informants)

1. In the Grand Canyon of the Colorado. The present burro range is restricted largely to the south side of the river from Red Canyon on the east to the Aztec Amphitheater area on the west. Only in the immediate area of lower Shinumo Creek and its tributaries are burros found in any numbers north of the river. The burros are almost entirely found below the rim except in the Pasture Wash and Cataract Canyon areas. 1,500–2,000. (Robert Bendt, Biologist, Grand Canyon National Park; Chester Bundy, Mt. Trumbull, Arizona; F. M. Hodgin, Forest Supervisor, Kaibab National Forest; Louis Schellbach, Park Naturalist, Grand Canyon National Park; Dale Slocum, Executive Secretary, Arizona Game Protective Association, Phoenix; Philip Wells, Park Naturalist, Lake Mead National Recreation Area.)

2. Panamint Mountains on the west side of Death Valley. The present range extends from the Owlshead Mountains on the south northward to Trail Canyon on the east side of the Panamints and to Wildrose and Wood canyons on the west side. 500–1,000. (Fred Binneweis, Superintendent, Death Valley National Monument; Vernon Burandt, Game Warden, California Department of Fish and Game, Lone Pine; Lou Hallock, Chief Ranger, Death Valley National Monument; Fred Jones, Game Manager, California Department of Fish and Game; Russ Leadabrand, writer, Pasadena, California; R. H. Petrie, Acting Range Manager, Bureau of Land Management, Bakersfield, California; Richard Weaver, Game Manager, California Department of Fish and Game; Ralph Welles, Ranger Naturalist, Death Valley National Monument.)

3. Saline Valley area. Includes the northern end of the Panamint Mountains from Cottonwood Canyon to the Ubehebe Crater area, all of Saline Valley, and the surrounding hills. 800–1,200. (Burandt; Jones; Weaver.)

4. Coso and Argus mountains, including portions of Panamint Valley. 300–400. (Burandt; Jones; Leadabrand; Petrie; Weaver.)

5. Includes most of the area between U.S. Highways 91 and 66, extending as far east as the Colorado River, and including the Dead and Newberry mountains of extreme southern Nevada. The greatest concentrations apparently are in the Providence Mountains, Granite Mountains, Kelso Peak, and Lanfair Valley areas. 500–2,000. (Dr. John Goodman, Assistant Professor of Biology, University of Redlands, Redlands, California; Jones; Petrie; Weaver.)

6. The immediate vicinity of Clark Mountain. 30–50. (Jones; Weaver.)

7. The northwestern portion of Arizona, encompassing primarily the Black Mountains and the rough country just south of Lake Mead. Also included are the north end of the Eldorado Range of southern Nevada, from Knob Hill on the south to Hoover Dam on the north. 250–700. (Al Jonez, District Supervisor, Nevada Game and Fish Commission, Las Vegas; Jim McDougal, Soil Conservation Service, Kingman, Arizona; E. M. Mercer, District Agent, Branch of Predator and Rodent Control, U.S. Fish and Wildlife Service, Phoenix, Arizona; Don Moon, District Game Ranger, Arizona Game and Fish Commission, Parker; O. L. Wallis, Supervisory Park Naturalist, Lake Mead National Recreation Area; Wells; J. T. Wright, Tucson; and Russo, 1956.)

8. The rough country immediately north of Lake Mead, particularly in the Muddy Mountains and Gold Butte area. 200–500. (Clair Aldous, Biologist, Desert Game Range; Jonez; Wallis.)

9. Between U.S. Highway 95 and the Colorado River, scattered throughout the Chemehuevi Mountains, Chemehuevi Wash, and the Whipple Mountains. 50–100. (Jones; Weaver.)

10. The triangular area between the Rio Grande and the Rio Chama, and north of their confluence. The greatest concentration apparently is around the head of Copper Canyon. 50–75. (W. S. Huey, Biologist, New Mexico Department of Game and Fish.)

11. South of Los Alamos and west of the Rio Grande, largely within the confines of Bandelier National Monument. 50–100. (P. A. Judge, Superintendent, Bandelier National Monument.)

12. On the Mesa Prieta to the east of the Rio Puerco. 50–100. (J. C. Gatlin, Regional Director, U.S. Fish and Wildlife Service, Albuquerque, New Mexico; Huey.)

13. In the Luera Mountains. 200–300. (Gatlin.)

14. In the vicinity of Elk Mountain. 100–150. (Gatlin.)

15. On the south side of the Colorado River between Havasu Creek on the east and Pierce Ferry on the west. This is largely within the Hualpai Indian Reservation. 50–150. (W. T. Bobo, Subagency Superintendent, Colorado River Indian Agency; Hodgin; Wells.)

16. An extensive area of western Arizona, including the Hualpai Mountains, Mohave Mountains, Buckskin Mountains, and the valleys of the Bill Williams and Santa Maria rivers. 100–250. (Mercer; Gale Monson, Refuge Manager, Kofa and Cabeza Prieta game ranges; Moon; J. M. Stewart, Superintendent, Colorado River Indian Agency; Wright; Russo, *op. cit.*)

17. The area around Wickenburg and Castle Hot Springs. 25–75. (Fred Leftwich, Forest Supervisor, Tonto National Forest; Mercer; Ted Schaffer, owner, Two Bars Seven Ranch, Castle Hot Springs, Arizona.)

18. An extensive area north and east of Tucson, including Black Mountain and the Galiuro Mountains. 50–150. (Leftwich; Mercer; L. K. Sowls, Leader, Arizona Cooperative Wildlife Research Unit, University of Arizona.)

19. An extensive area between Hickiwan and the Mexican border, largely within Organ Pipe Cactus National Monument. 10–25. (H. W. Gilmore, Superintendent, Papago Indian Agency; W. A. Haskell, Administrative Assistant, Organ Pipe Cactus National Monument; Charles Pitrat, Range Conservationist, Bureau of Indian Affairs, Polacca, Arizona.)

20. The Mohawk Valley and Mohawk Mountains area. 10–25. (Mercer; Moon.)

21. An area including the Kofa, Castle Dome, Chocolate, Trigo, and Dome Rock mountains, and extending westward to the Colorado River. 150–300. (Arthur Halloran, Biologist, Wichita Mountains National Wildlife Refuge; Mercer; Monson; Moon; Russo, *op. cit.*)

22. The southwestern corner of California, including the Chocolate Mountains, Mule Mountains, Palo Verde Mountains, and the Quartz Peak and Picacho Peak areas. 50–100. (R. M. Howie, Riverside County Agricultural Commissioner, Riverside, California; Jones; Leadabrand; Weaver; Harley Wells, Blythe, California.)

23. An extensive area along the northeast side of the San Bernardino and Little San Bernardino mountains. 10–50. (S. E. Jarvi, Forest Supervisor, San Bernardino National Forest; Jones.)

24. The eastern side of the southern end of the Sierra Nevada, from Walker Pass in the north to the Tehachapi area in the south. 75–125. (Jones; Weaver.)

25. The Avawatz Mountains. 20–30. (Jones; Weaver.)

26. An area extending from the vicinity of Goldfield,

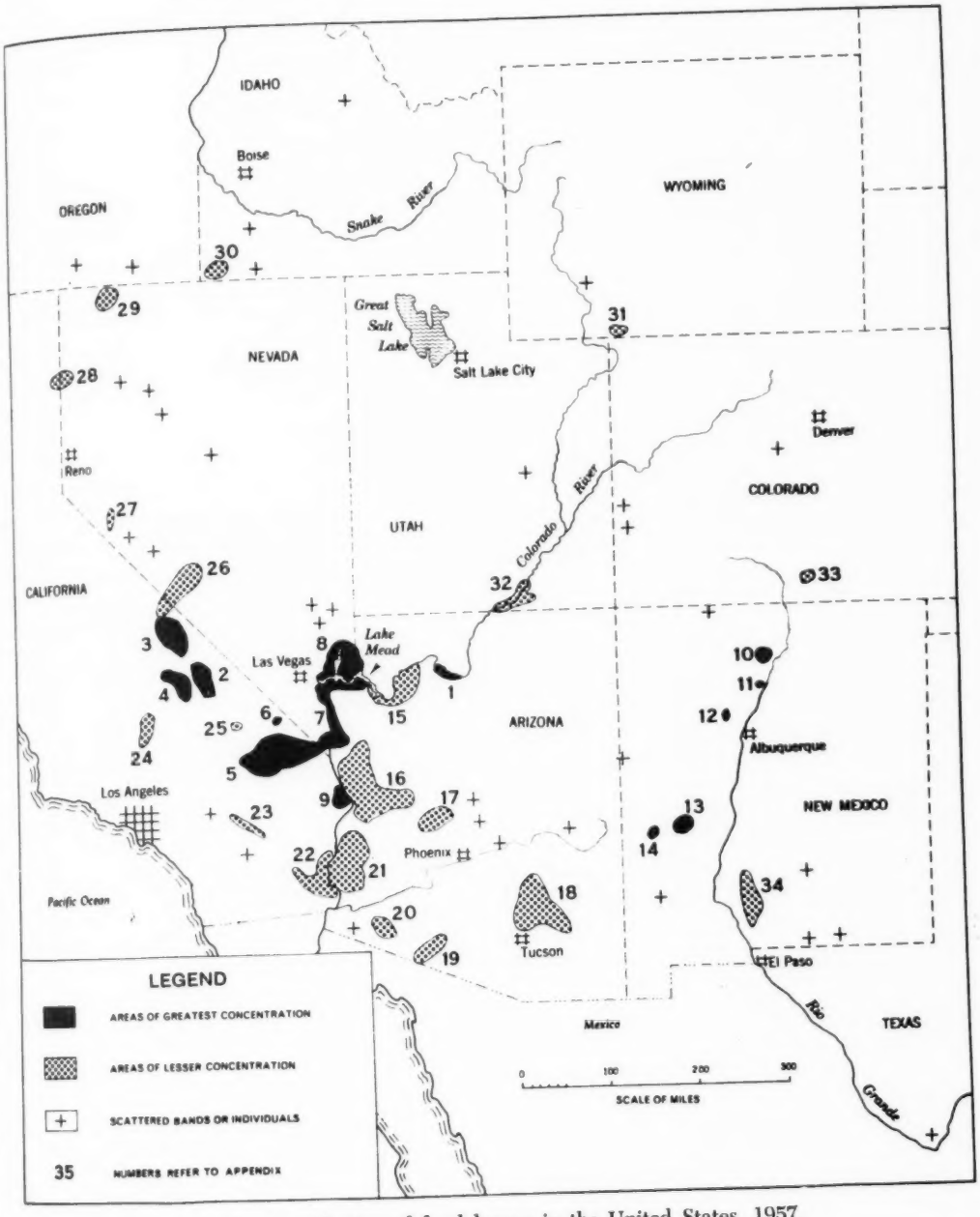

FIG. 1. Distribution of feral burros in the United States, 1957.

Nevada, to the Eureka Valley of California. 50–100. (M. G. Barlow, County Clerk, Hawthorne, Nevada; Jones.)

27. That portion of the Wassuk Range centering around Mt. Grant. 30–40. (Fred Batchelder, County Agricultural Agent, Yerington, Nevada; L. A. Gardella, County Agricultural Agent, Reno, Nevada.)

28. An area extending from the Smoke Creek Desert of Nevada to the vicinity of Ravendale, California. 50–100. (Jones; J. L. Kirk, Range Manager, Bureau of Land Management, Ely, Nevada; N. M. Rahm, Forest Supervisor, Modoc National Forest; H. B. Rathner, Range Manager, Bureau of Land Management, Susanville, California.)

29. On the Charles Sheldon Antelope Range, especially around Virgin Valley and Thousand Creek. 25–50. (Aldous; B. M. Hazeltine, Refuge Manager, Sheldon National Antelope Refuge; Dale Naylor, Range Manager, Bureau of Land Management, Winnemucca, Nevada; Mark McBride, Acting Range Manager, Bureau of Land Management, Burns,

sparse vegetation, and rigorous climate, is by no means uniform. There is considerable variation in summer temperature (cf. California's Death Valley and Colorado's South Park), winter temperature (cf. Arizona's Gila Mountains and Idaho's Owyhee Canyon), terrain (cf. Arizona's Grand Canyon and Nevada's Smoke Creek Desert), natural vegetation (cf. California's Chemehuevi Wash and New Mexico's Carracas Mesa), and elevation (cf. California's Barton Flats and Arizona's Mohawk Valley). Such variations lead to the inescapable conclusion that the feral burro is not only hardy, but also adaptable. This is a keynote to understanding both its existence and the problems it causes.

Although widely distributed and occupying a variety of types of terrain, wild burros are particularly characteristic of certain landform associations. In the so-called basin-and-range portion of the West (which includes southeastern California, most of Nevada, and southwestern Arizona), burros are found almost exclusively in association with desert mountains. Their range is typically within the steep-walled canyons that dissect the mountains and to a lesser extent on the alluvial fans that fringe them. They are sometimes found in the highland portions of the mountains (i.e. above the canyons), but such occurrences are less common. Although sure-footed and sturdy, burros do not have the proclivity of bighorn sheep (*Ovis canadensis*) for rugged terrain, and therefore tend to stay out of the extremely rough areas. In like manner, burros do not frequent the flats (bolson floors, etc.) that characteristically surround most of the mountains. This is probably a measure of their dependence on water holes, which are usually in the canyons or on the fans, as burros are more likely to be found wandering on the flats in winter (when water is not so important) than in summer. Outside the basin-and-range country, generalizations concerning burro habitat are less valid. In general, it can be said that they tend to inhabit canyons and arroyos of hilly or mountainous terrain.

Although records as yet are inconclusive, the writer believes that burros make only minor seasonal changes in their range (this conclusion is supported by opinions from 15 of 18 southwestern naturalists to whom the question was posed). There are practically no documented instances of a regular seasonal migration of burro bands, but general seasonal movements have been observed in a number of areas. Most characteristic seems to be a patternless drift toward the higher elevations in summer and a return to lower levels in winter (Lowell Sumner, pers. comm.). In addition, there is distinct clustering around water holes during the hot months. Thus, when the weather becomes severe in the highlands, burros tend to move lower, although there have been winter observations of burros in snow-covered timberlands at high elevations (Ralph Welles, pers. interview). And during the long summers, the animals tend to stay above the flats and fans to escape the heat. However, in many areas burros seem to pay no attention whatsoever to weather changes and make no seasonal movements.

HABITS

One of the characteristics of burro behavior that permits this species to exist in

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Oregon; T. J. Snyder, Co. Agric. Agent, Lovelock, Nev.

30. In the Owyhee River Canyon country of extreme southwestern Idaho. 20–30. (Mac Hulls, Salmon, Idaho; J. R. Penny, State Supervisor, Bureau of Land Management, Boise, Idaho; William Strickland, Bruneau, Idaho.)

31. Along the drainage area between Vermilion Creek and Salt Wells Creek in extreme southern Wyoming south of Rock Springs. 25–50. (Dewey Henderson, Game Warden, Wyoming Game and Fish Commission, Rock Springs, Wyoming; George W. Reynolds, Information and Education Officer, Wyoming Game and Fish Commission.)

32. Along the Colorado and San Juan rivers for some distance both upstream and downstream from their confluence. 50–150. (M. H. Galt, Range Manager, Bureau of Land Management, Kanab, Utah; P. A. Krause, Range Conservationist, Navajo Indian Agency.)

33. In the Fort Garland portion of the San Luis Valley, Costilla County, Colorado. 30–40. (A. J. Relyea, County Agricultural Agent, San Luis, Colorado.)

34. In the San Andres and Organ mountains and adjacent portions of the Tularosa Basin. 25–75. (J. R. Ahl, retired range manager, Alamogordo, New Mexico; J. M. Bell, Manager, Chamber of Commerce, Alamogordo, New Mexico; H. F. Danley, Alamogordo, New Mexico; Ralph Dunlap, County Extension Agent, Carrizozo, New Mexico; F. J. Monighan, Forest Supervisor, Cibola National Forest.)

the arid West is a voracious and nondiscriminating appetite. It has been said that when burros find no palatable plants available, they will eat the unpalatable ones. This is almost literally true. Although burros naturally prefer the more palatable vegetation, they seem to be able to eke out an existence utilizing almost any plant that grows. There have even been observed instances of burros feeding on creosote bush, which is so unpalatable that no other mammal is known to do more than occasionally nip it, even under starvation conditions (L. Sumner, pers. comm.). However, eating inferior forage is likely to have a debilitating effect on the animals, which results in a lack of vitality, inability to run far, and sometimes even sickness and death. In general, burros are wasteful foragers, frequently pulling entire plants up by the roots, eating only one or two mouthfuls, and dropping the remains on the ground (Lou Hallock, pers. interview).

Availability of water is the key to existence in much of the West; this is a generalization that applies as much to wild burros as to any other animal. Some desert mountain ranges have no water during the summer months, and as a result they are devoid of burros and most other animal life. Burros depend upon water holes (springs, seeps, etc.) or exotic streams (i.e. arid-region streams with headwaters in more humid regions) over most of their range, particularly in the summer. Easily the most important of the exotic streams is the Colorado River, which serves as a major watering place for burros throughout its course from southern Utah to Mexico. It is heavily used except where the sides of the canyons are too steep (i.e. much of the inner gorge of the Grand Canyon). The several dams on the Colorado have added to the accessibility of its waters. The significance of water is maximized in summer and minimized in winter. The cool months generally have more rain and less evaporation, resulting in more available water and less need for it by desert dwellers. Thus in winter, burros may wander more widely than in summer, when watering needs are more pressing. It is generally believed that burros are unlikely to range more than 5 or 6 miles from a watering place during the hot months. Indeed, they tend to congregate around water holes, sometimes for hours on end, a habit apparently not shared by other western ungulates. When hard-pressed for water, burros will sometimes dig in the dry beds of washes and arroyos, their powerful hooves enabling them to penetrate as much as 4 or 5 feet downward (personal observation). Their search is frequently successful. Unfortunately for other animals of the dry lands, burros are untidy water-users. Their protracted stays at water holes commonly result in destruction of most of the surrounding oasis vegetation, deflocculation and packing of the soil, roiling of the water, and heavy pollution of the water hole by defecation (Dixon and Sumner, 1939; Jaeger, 1950; Ferry, 1955). These habits contribute significantly to the unpopularity of the burro.

Little is actually known about the reproductive habits of feral burros. The assumption is that the mating traits of wild asses are not significantly different from those of domestic ones; however, it seems unfortunate that these matters have not as yet been studied. There seems to be agreement among competent observers that rutting usually occurs in the fall and foaling in the spring. However, this seasonality is not marked, and rutting apparently may take place at any time during the year. There seem to be no reliable reports of the length of the gestation period in feral asses, although it is assumed to be about the same as that for domestic asses, i.e. 11 or 12 months. According to T. Donald Carter (pers. comm.), "The domestic ass takes from 331 to 385 days according to different authorities, the average being just over a year. The Somali wild ass is recorded as 365 days." If this is correct, then the likelihood of a regular fall rutting season is diminished, and it seems more likely that rutting would occur in the late spring or early summer. Several observers have reported that they have never seen young colts except in the spring, and others have made a point

of the fact that they have witnessed jacks fighting over a jenny with a colt only a few days old. Not much is known about the actual rutting habits of wild burros, but incomplete reports seem to indicate that a jack will seek to gather a harem of jennies, will fight other jacks, etc., much in the manner of wild horses. There seems to be a tendency to breed every year, even if range conditions are poor, a situation that sometimes discourages breeding by other ungulates (Richard Weaver, pers. interview).

Predation, other than by man, appears to be an insignificant factor in determining wild burro populations. The only predators capable of taking a mature burro are cougars (*Felis concolor*), wolves (*Canis lupus*), and jaguars (*Felis onca*), and all three are largely extirpated in the areas where burros now exist in the United States. It is possible that coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and eagles (*Aquila chrysaetos*) take an occasional young or weakened burro. The writer is of the opinion that feral burros on the whole are little bothered by parasites and diseases, although he is aware of no pertinent studies, and this may be more of a factor than is suspected. There is undoubtedly some winter kill, resulting from a combination of exposure and starvation, particularly in the northern extremities of the burro range. However, all of these factors combined result in only a minor proportion of burro deaths; man is the principal cause (Philip Wells, pers. interview).

COMPETITION

The most significant single problem associated with feral burros in the United States today involves the competition they provide other animals for food and water. Burros are relatively large animals and consume a considerable amount of herbage, an important consideration in arid and semi-arid environments where forage resources are limited. The crux of the problem is that the burro is an introduced exotic, and prospers more or less at the expense of native fauna and domestic livestock. In addition, the scarcity of water and the displeasing mannerisms of burros at water holes compound the problem.

It has been pointed out above that burros are remarkably adaptable, adjusting themselves to extremes of weather and climate, notable topographic differences, and variations in quantity and quality of diet. A virtual absence of predators and relatively prolific breeding habits result in fairly rapid population increases. The burro is thus a hardy competitor, capable of assuming a role of dominance in determining the fate of the natural vegetation and most of the herbivorous animals in a given area. Under present and foreseeable conditions, burro competition can only be controlled by man.

Burro habitat overlaps that of several important native species. In essence, the competition is between burros and most other animals that utilize water or forage in the areas of overlapping habitat. Practically speaking, the competition is between (1) burros and (2) ground birds and ungulates.

Most desert birds depend on grassy or shrubby cover for nests and concealment. Such cover is particularly necessary around water holes, as it provides both protection and avenues of concealed access to water. However, when burros congregate around water holes, a usual result is the removal of much of the nearby vegetative cover, either from browsing or trampling. This destruction is detrimental to all ground birds (as well as some small animals), but is noticed particularly with respect to quail.

Burro habitat overlaps to some extent with that of three native ungulates in the West today: deer (*Odocoileus hemionus*), pronghorns (*Antilocarpa americana*), and bighorn sheep. (1) Competition with burros seems to pose a threat to deer in only a few scattered areas, and is only a minor problem. Although there is some overlap of burro and deer range in at least eight of the ten states where wild burros are found (Oregon and Wyoming being the possible exceptions), the scope of the competition is usually small. (2) In parts of Nevada, Arizona, New Mexico, Oregon, and Wyoming, feral burros come in contact with pronghorns on the range. However, the typical

habitat occupied by the two is usually different, and again the problems created may be considered to be minor, with a few exceptions. (3) Bighorn sheep and burros occupy the same ranges extensively in California, Arizona, Nevada, and possibly Texas. It is in these states that the burro seems to be most detrimental, and it is this aspect of the broader problem that has attracted the most attention.

The desert mountain ranges of southeastern California, southern Nevada, and Arizona (plus small portions of neighboring states) constitute the last strongholds of bighorns in the Southwest. Much has been written about these animals (Russo, 1956; Davis and Taylor, 1939). In point of fact, burros and bighorns frequently compete on the same range, usually to the detriment of the bighorn. Theoretically, the bighorn is perhaps hardier than the burro, as it can inhabit rougher terrain and presumably has fewer watering needs. However, where there is competition between the two, it is the bighorn that yields (Dixon and Sumner, *op. cit.*; Ferry, *op. cit.*; Jaeger, *op. cit.*; McKnight, *op. cit.*; Sumner, 1952; Dodge, 1951). There seem to be four principal reasons for this. (1) The dietary limits of the burro are more flexible than those of the bighorn. It has been pointed out above that burros eat almost any edible vegetation. Bighorn sheep cannot subsist on some foods that would sustain burros (Russo, *op. cit.*). (2) The author believes that bighorns have a higher mortality rate from parasites and disease than burros. (3) Burros are probably more successful than bighorns in raising their young to maturity. Infant mortality is usually high among bighorn sheep, partially from predation, partially from climatic causes (bighorn lambing grounds are usually at higher altitudes than the places where burro colts are born), and partially from diseases. Burro colts, on the other hand, are more likely to escape infant mortality, although this generalization is based largely on speculation. (4) Perhaps most important of all is the "social attitude" of the two animals involved. The bighorn is shy, flighty, nervous, and intolerant. It is inclined to vacate a competitive situation. Burro concentrations around water holes are avoided by the bighorn. Rather than tolerate such conditions, the bighorn frequently will move to another area. The burro, on the other hand, is stolid, patient, relatively insensitive, and seems to thrive on competition.

The situation in the Death Valley area typifies the problem. The Panamint Mountains, on the west side of the valley proper, are heavily utilized by burros but are practically devoid of bighorn sheep. However, the ranges on the east side of the valley contain no burros, and have a considerable population of sheep. Willow Spring is a case in point.

> In 1935, this [Willow Spring] was one of the best and cleanest water supplies in the region. Now [1938] it is so trampled and muddy [by burros] that we could not find a place for a man to drink. . . . Careful search in the vicinity failed to reveal any bighorn tracks or droppings and it is our belief that the sheep have been crowded out of the area by the large numbers of burros which water there (Dixon and Sumner, *op. cit.*:81).

However, when the burros disappeared from Willow Spring, the sheep made a comeback.

> Since I have been in Inyo County I have spent considerable time studying desert sheep and also checked Willow Spring frequently. At the present time [1957] there are no burros at Willow Spring! And now Willow Spring supports a large sheep population. I have been told the wild burros were trapped out of this area prior to World War II, and since this is an isolated area, other burros haven't drifted back (Vernon Burandt, pers. comm.).

Such an experience seems to be commonplace.

> . . . . it was our experience throughout the Death Valley region that whenever we found a spring that was heavily utilized and fouled by a large number of burros or wild horses, no evidence of bighorn watering there could be found (Dixon and Sumner, *op. cit.*:83).

> Places where the bighorns of Death Valley still come habitually to drink have one significant feature in common—they are not visited by wild burros (Sumner, *op. cit.*:3).

Such conditions are not limited to Death Valley, or even to California. Russo (*op. cit.*) reports heavy competition between

burros and Arizona bighorn sheep in the Buckskin, Kofa, Black, and Rawhide mountains, as well as in Grand Canyon and the vicinity of Lake Mead. Similar conditions apparently prevail in portions of Nevada.

> Either eliminate the burro from actual or potential bighorn ranges or else write the desert bighorn off as another lost American game animal. I don't think there is room for both in areas suitable for bighorn—which probably include nearly all areas that are inhabited by the burro.
>
> If public opinion thinks the burro should stay, then okay, but make it a matter of choice, as I believe it is, either the feral burro or the native bighorn. Whichever we decide upon, we still must apply management measures, as with any other big game animal, to keep their numbers in balance with available forage (Gordon Gullion, pers. comm.).

Two further quotations indicate the unanimity of opinion.

> . . . wherever the bighorn and the burro have overlapped in their range, the bighorn has invariably been crowded out (Ferry, *op. cit.*:19).
>
> As the burros increase, and that increase is often rapid, the sheep decrease. In some areas the burros have brought the entire sheep population almost to the point of extinction (Jaeger, *op. cit.*:35).

Of more economic significance is the competition that exists between burros and domestic livestock. Several stockmen questioned by the writer claimed that the amount eaten by burros on their range land greatly decreased the stocking capacity of the land; others reported no detrimental results. Such diversity of claims is at least in part a reflection of the burro concentration on the lands involved.

The broad aspect of this problem of competition revolves around vegetation rather than animals. In some instances, the presence of burros is detrimental to bighorn sheep, quail, cattle, etc., but wherever burros are concentrated, the native vegetation suffers. It is a simple matter of overgrazing, with resultant accelerated soil erosion.

CONTROL

The present population of burros in the West is believed to be considerably less than it was in the past several decades. Although no detailed studies have been made of past burro concentrations, there are enough scattered reports to validate the conclusion that in most areas there has been a general decline of considerable magnitude in burro numbers (of 33 informants questioned on this point, 94 per cent stated that the burro population had decreased considerably in their area of knowledge). As predators play only a minor role in burro control and disease seems to be a negligible factor, it appears that depletion of the range and deliberate control by man are the principal causes of this decline.

Desert range land may deteriorate relatively quickly because of overuse, and may require decades to recover (Stoddard and Smith, 1943:244–245). Where concentration of burros (or other animals) has badly depleted the forage, the carrying capacity of the range may be seriously restricted. This not only weakens the remaining burros, but reduces their fecundity as well. In areas where most edible plants have been removed, burros have been observed to become thin and gaunt, and their reproductive capacities undoubtedly are impaired (L. Sumner, pers. comm.).

Burros have been removed from the open range by man in four ways: (1) shooting, (2) poisoning, (3) capturing alive, and (4) accidental killing. Shooting has caused a large proportion of the decrease in population. Most of it has involved deliberate campaigns to reduce the concentration of burros from seemingly overcrowded range lands. It has been carried on by government personnel (both federal and state) and by ranchers. In addition, some burros have been shot for meat (both for table use and for the preparation of pet food), and some have been killed simply as an exercise in target-shooting (Davis, 1953). Poisoned grain and poisoned salt have been used occasionally. Burros have been captured alive for purposes of domestication, slaughtering, and simply to provide round-up thrills for dude ranchers (DeWald, 1956). Accidental killing is largely the result of automobiles striking burros that choose inopportune times to cross highways.

Deliberate shooting and poisoning of burros has been practiced extensively in the

Southwest. In some areas meat hunting has been a major factor. Burro meat has been used widely in the Southwest for pet food and as a bulk item for feeding foxes and mink raised on fur farms. Also, burro control has been practiced by wildlife technicians who have felt the necessity of protecting water holes and forage resources in general or bighorn sheep in particular. However, the majority of cases involving burro removal have involved range lands utilized by livestock. Individual ranchers have undertaken to rid or greatly reduce the burro concentrations on their lands. There have been recorded instances of ranchers removing more than one hundred burros per year for several years from their grazing lands (Gordon Gullion, pers. comm.). Also, state and federal grazing officials (particularly employees of the Bureau of Land Management) have organized systematic campaigns to improve grazing lands for livestock by removing unowned stock (both burros and horses). Such campaigns have been particularly effective in New Mexico and Nevada.

So far there has been only one serious attempt to encourage the hunting of wild burros as game animals, and it was a failure. In 1952, the California Department of Fish and Game issued a press release pointing out the presence of wild burros in some of California's desert ranges, and suggesting that they were acceptable game animals, protected by no closed season or bag total (anon., 1953). This resulted in a few hunters taking to the field after burros, and a flurry of heated protests. In many instances, the burros that were shot were left lying where they fell (Davis, *op. cit.*). This sort of treatment precipitated a tremendous hue and cry from desert dwellers, humane organizations, and interested citizens in general. In early 1953, a bill was introduced into the legislature making it a state offense to kill burros in California (Leadabrand, 1956). This so-called "burro law," passed as a temporary measure, is now a permanent part of the state Fish and Game Code.

No other state has recognized the wild burro in its game laws, either by providing for its protection or by declaring it a game animal. Outside of California, it is generally legal to kill or capture feral burros at will on the open range, providing there is no doubt that the animals are unowned. Most states have some sort of arrangement whereby the owners of branded animals are assured redress in case one of their burros is killed by mistake. In Nevada, for example, anyone desiring to kill feral burros must post a bond in the county commissioner's office (Al Jonez, pers. interview).

At the present time a burro-protection law has been proposed in Arizona (Willson, 1957), and there is some enthusiasm for similar action in Nevada. However, it is doubtful that such legislation will be enacted, as the example of California has shown that such a law is too restrictive to prove satisfactory. Except in curbing target-shooters, the California law has created more problems than it has solved. Where burro concentrations are too great, such a law enormously complicates successful wildlife management; where concentrations are smaller, the law generally is superfluous.

OUTLOOK

At the present writing, the future of feral burros in the United States is not clear. They have been largely ignored by wildlife-management authorities, except for shooting and poisoning in areas of heavy concentration. No careful studies have been made of their ecology, and their relationships with the native vegetation and other fauna are only imperfectly known. Detailed management plans have not been developed, although various suggestions have been made. However, because burros are relatively large animals, inhabit portions of ten states, are numbered in the thousands, and play vital roles in the biotic dramas of the arid and semiarid West, it is manifest that such plans are necessary for proper solutions.

The various management plans that have been advanced can be grouped into four categories: (1) extermination, (2) complete protection, (3) classification as a game animal, and (4) establishment of one or more burro sanctuaries.

1) Complete extermination of feral burros in the United States is advocated by a considerable number of people, particularly ranchers. Man is responsible for the presence of feral burros in this country, and it is probably within man's capabilities to exterminate them. These animals are not only exotic but also feral, and therefore exert an alien influence on the native biotic community which can only be "unnatural" and harmful. Theoretically, such views appear to have considerable merit, but there are several practical objections. In the first place, a deliberate extermination campaign for any creature, no matter how obnoxious, seems ill-advised and would undoubtedly face strong objections from many quarters. Secondly, burros contributed a great deal to the early development of the West and it seems fitting to accord them a better fate than extermination. In the third place, there are many areas occupied by burros where no large native mammals are found. The presence of a moderate burro population would add to the interest in such areas. Fourthly, extermination would be difficult to accomplish in some of the more inaccessible regions.

2) At the opposite extreme from the advocates of extermination are the protectionists. They propose that the burros should be rigidly protected from any further reduction in numbers, arguing that the damage charged to them is greatly exaggerated. Weight and Weight (*op. cit.*) suggest that the bighorn sheep is no less an exotic than the burro, having crossed to North America by the Siberian "land bridge," and therefore subject to no more consideration than the burro. In addition, it is pointed out that the range of bighorn and burros overlaps only in some areas. Unfortunately, the views of the extreme protectionists are not always rooted in sound reasoning. Every biologist who has studied the situation has become convinced that a heavy concentration of burros is detrimental to both the vegetation and to other herbivorous animals in the area. Unchecked increases of the burro population could only result in eventual starvation for the burros themselves, unless a vast artificial feeding program (one of the most unsatisfactory of all wildlife-management practices) was undertaken.

3) Superficially, at least, the possibility of declaring the burro a game animal and instituting legalized hunting is an attractive one. Presumably, it would serve both as a check or unwarranted increase in the burro population and as another hunting outlet for "sportsmen." This is a procedure based on sound wildlife-management principles, and one that has been used more or less successfully with many of our larger animals. Deeper reflection, however, encounters several objections to this proposal, which, when considered together, present a rather formidable barrier. Regardless of game laws, there is undoubtedly a large segment of the population that would never consider the burro as fair game for sport hunting. It lacks horns or antlers and its facial features are not unique enough to make it attractive as a trophy animal. The meat is palatable and sometimes flavorable, but is not likely to be a great inducement for meat hunting. In addition, burros generally are thought of in the same terms as barnyard animals, and thus as being unfit for hunting. Further, many Westerners would as soon shoot a horse or cow as a burro. Deliberate sport hunting of "man's uncomplaining servant and the playmate of his children" (Weight and Weight, 1953) would meet with strenuous objections from many parts of the country. A more practical, although certainly no more real, impediment is the problem of the occasional branded animal that might be shot. In many instances it is quite difficult to differentiate between owned and unowned burros, and legal problems undoubtedly would develop. However, it seems logical that this solution has some merit. If it is necessary to exert artificial control in areas of dense burro concentration, public hunting might prove more satisfactory (at least in some cases) than systematic shooting and poisoning by game wardens, etc.

4) Another possible management plan involves the establishment of one or several burro refuges or sanctuaries—limited areas

where full protection is granted the burros. A measure passed by the California legislature in 1957 established a major burro sanctuary in the Saline Valley–Panamint Valley–Death Valley areas (Leadabrand, 1957). This is patterned after other specialized wildlife refuges designed specifically to protect such animals as antelope, elk, bighorn sheep, waterfowl, etc. Although the idea is an interesting one, the practical difficulties of maintaining such a sanctuary in functional use are staggering. Keeping the burros within the sanctuary boundaries presents a major difficulty that can probably be solved only by miles of expensive fencing. It is true there are several desert mountain ranges in California, Arizona, and Nevada that might serve as burro refuges without endangering the present (although not the potential) ranges of bighorn sheep, antelope, or deer. However, a concentration of burros in a sanctuary would eventually become an overconcentration which would lead inevitably to the burros' depleting their own range to such an extent that strong measures would be needed to prevent wholesale starvation. On a limited scale, a burro refuge might be worthwhile, but as a total solution it would be wholly inadequate.

It is obvious that none of the above solutions is satisfactory in itself, and that some sort of workable compromise is needed. Actually, a compromise of sorts is now in effect in all states save California, although management policies with regard to burros are more negative than otherwise. In analyzing the management policies existing today with regard to feral burros in the United States, some attention must be given to the varieties of areas involved:

1) Areas administered by the National Park Service have a unique and specialized function in this country, and burro management on these lands deserves special consideration. Specifically included are Big Bend National Park in Texas; Bandelier National Monument in New Mexico; Grand Canyon National Park, Grand Canyon National Monument, and Organ Pipe Cactus National Monument in Arizona; Lake Mead National Recreation Area in Nevada–Arizona; and Death Valley National Monument in California. Burros are heavily concentrated in four of these units (Bandelier, Grand Canyon Park, Lake Mead, and Death Valley). The wildlife policy of the Park Service is explicit with respect to exotic animals:

> Any exotic species which has already become established in a park shall be either eliminated or held to a minimum provided complete eradication is not feasible; and the possible invasion of the parks by other exotics shall be anticipated and steps taken to guard against same (National Park Service, 1955).

This policy generally has been followed; burros apparently have been completely eliminated from Carlsbad Caverns National Park in New Mexico, most of them are gone from Big Bend National Park, and strong efforts have been made to curb the increase at Death Valley and Grand Canyon, and to a lesser extent at Lake Mead and Organ Pipe. The national park system was established to preserve as much of the natural biota as possible and the Service's management policy with respect to exotics seems quite sensible. Some areas should probably follow the example of Death Valley and maintain at least small representations of wild burros (generally controlled to keep them in a relatively small area) because of the historical interest involved. Others, such as Big Bend and Grand Canyon, might well support minor burro populations under sporadic control in areas not well suited to native ungulates. Other than these exceptions, wild burros probably should be rigidly controlled in Park Service areas.

2) Burros occur in certain major federal wildlife refuges in the Southwest. Many are found in Kofa Game Range in Arizona. They occur in limited numbers in Cabeza Prieta Game Range in Arizona; Desert Game Range, Charles Sheldon National Antelope Refuge, and Charles Sheldon Antelope Range in Nevada; and Hart Mountain National Antelope Refuge in Oregon. These large refuges have been set aside as specialized areas to protect certain endangered species. Kofa, Cabeza Prieta, and the Desert

game ranges are designed specifically for desert bighorn sheep, whereas the Sheldon range and refuge and Hart Mountain provide protection specifically for pronghorns. Other wildlife forms enjoy the protection of these refuges, but if any species poses a threat to the animals for which the refuges were specifically designed, that species deserves rigid control. So far, burros have become a nuisance only at Cabeza Prieta and Kofa, and on the former they have largely been eliminated.

3) It is outside the wildlife refuges and the national parks and monuments that sound management policies for burros are needed most urgently.

Colorado, Idaho, Oregon, Utah, and Wyoming are the five states (Texas is not included here, as its wild burros are confined to Big Bend National Park) that have small burro populations. As far as can be determined, no problems are found nor does there seem to be a tendency for rapid growth of the burro population in any of these areas. The burros should be kept under surveillance, but the numbers are too small to warrant concern.

The situation in Arizona, Nevada, and New Mexico is different in that there are major concentrations of burros in parts of these three states. None of the three gives any protection to wild burros, and sporadic to systematic killing is carried on by ranchers, game wardens, etc., whenever the situation seems to warrant it. In addition, burros are sometimes killed for other reasons than to protect the range. For example, a "wild burro barbecue" has been held in Bullhead City, Arizona, every spring since 1954, primarily to attract visitors to that town (anon., 1957). It is probable that the burros are overly concentrated in a relatively few areas, but if given a large degree of protection, they might present problems in many other areas as well.

California presents still a different situation, as the Mojave Desert country of the southeastern part of the state contains many burros, and they are afforded complete protection by the state's burro law. In addition to Death Valley National Monument, there are several areas where overconcentration of burros has seriously depleted the range and provided drastic competition for bighorn sheep. Prior to 1953, it had been common among California wildlife managers to practice sporadic unofficial containment measures in areas of dense burro population. After the possibility of burro hunting as a sport was brought to public attention by the previously mentioned news release, some target practice was carried on in the desert at the burros' expense. This precipitated the enactment of the original burro law, and has resulted in effectively curbing all burro control, except in Death Valley National Monument. Thus, California is in the unique position of having a feral, exotic species that is given almost complete protection in spite of the fact that local populations are causing major damage to the natural vegetative cover and watersheds, and indirectly impairing the already-slim chances for survival of native wildlife species.

RECOMMENDATIONS

1) It is time that ecologists and naturalists became fully cognizant of the fact that feral burros exist in many portions of the arid and semiarid West. In some states they are even more numerous than some of the larger native species (Ingles, *op. cit.*). No comprehensive management plans can be effected until it is realized that burros are, for better or for worse, a contemporary member of the fauna of ten states, and are likely to remain so for some time to come in at least three of these states. Acceptance of this fact is the first step.

2) The lack of basic knowledge of feral burros presents a major handicap to the development of an effective pattern of management. Much research needs to be carried on, from biological, ecological, and historical standpoints. How much does a wild burro eat? How does this compare with the range requirements of a domestic cow or a bighorn sheep? What is the reproductive cycle of feral burros? Are there any effective pathological checks on their population? How dependent are burros on water

during the summer? During the winter? How far will burros disperse if their habitat becomes depleted? Do they undertake important seasonal migrations? Do many burros die from exposure, either during the hot months or during the cold months? How much does burro competition limit or inhibit population growth among bighorn sheep? What effects do range and cover decimation by burros have on the population of ground birds? What methods could be devised to make water holes for bighorn sheep and birds inaccessible for burros (*see* Halloran and Deming, 1956)? How extensive was the peak distribution of feral burros in the United States? What is the condition of the range now where burros once were numerous but have been removed? These and many other questions need definitive answers to aid the range and wildlife managers in their planning.

3) Burro-control programs that are current or planned in the various national parks and monuments and in federal wildlife refuges should be continued. These areas have specialized purposes and should be governed by the broad principles designed for their greatest benefit.

4) The possibility of a limited legalized hunting season on wild burros in parts of the West should not be abandoned without careful study. A regular hunting season might be feasible in Arizona, California, or Nevada. It is a recognized fact that once a legal hunting season (no matter how limited) is instituted for a species, interest in that species is greatly heightened, and the procuring of funds for the proper management of that species is expedited. The writer feels personally that legalized burro hunting is an unsatisfactory solution, but would like to see a careful study made of the question.

5) The possibility of establishing a workable pilot burro sanctuary should be explored. (The one that has been created by legislation in California is much too large and dangerously unmanageable.) It is probable that some isolated desert mountain range, containing no bighorn sheep, could be obtained (preferably in southeastern California, where "protectionist" sentiments seem to be strongest, but alternatively in western Arizona or southern Nevada) for use as a test area. The prohibitive cost of fencing could probably be avoided by careful control measures around the margins of the refuge area. Adequate patrol, management, and study of such a sanctuary would be an expensive undertaking, but the writer believes that a considerable share of the cost could be borne by public subscription. Burros would have to be managed even in the refuge or their rapid increase would destroy their own food supply.

6) The public needs to be educated to the necessity for controlling the size of burro concentrations. No matter what management plans are ultimately adopted, overconcentration will result in overgrazing and necessitate control. Without some sort of controls (i.e. shooting, poisoning, trapping) maintenance (without artificial feeding) of a wild burro population is impossible. The public must be educated to these principles in order to understand and appreciate the management measures that are necessary.

7) California's burro law should be repealed or at least modified to permit control in crucial areas.

8) In some states, game laws are enacted by the legislature rather than by a state game and fish commission. Generally this means that game regulations are decided upon by politicians rather than technicians, a situation that is not only inherently unsound but is subject to considerable abuse. This is as deleterious to burro management as to any other phase of wildlife management in the affected states. Enactment of game and fish regulations should be vested solely in game and fish commissions.

9) Definite steps should be taken to limit the size and rate of expansion of burro population in areas of overconcentration or critical bighorn sheep ranges. This should be handled entirely, or at least supervised, by the state game and fish commissions. It might involve shooting, poisoning, trapping, or making water holes inaccessible to burros. No matter what other management plans are adopted, this is likely to be the most

feasible and satisfactory. It is wholly illogical to allow the feral burro to become the dominant wildlife form in much of the Southwest simply because it could, if given the opportunity.

SUMMARY

Brought to North America during the early years of colonization, domesticated asses were soon found to be well suited for use as pack animals in the dry Southwest. However, with the advent of improved means of transportation, burros were frequently turned out on the range to shift for themselves. Being hardy and adaptable, they took readily to a feral existence.

Utilizing an extensive mail-questionnaire survey, plus field interviews and observations, the writer was able to determine the approximate distribution and numbers of feral burros in the United States. These now total between 5,500 and 13,000. The greatest numbers are in California, Arizona, and Nevada, with smaller populations in seven other states. For the most part, the burros inhabit steep-sided canyons and other rugged terrain.

A great variety of plants is included in the burro diet, including some with very low nutritional value. Availability of water is the key to existence in the desert, but burros spoil the water holes for other animals by trampling the area and befouling the water. Although details are obscure, it seems that burros tend to breed in late spring or early summer, foaling some 11 or 12 months later. There are few predators remaining in the Southwest that are capable of acting as a check on the burro population; hence, depletion of the range by overuse and deliberate control by man are the principal factors limiting the growth of the burro population.

The chief problem associated with the presence of these feral asses is the competition they offer for food and water with other animals, and their proclivity for denuding the vegetation and accelerating erosion in areas of concentration. As the burros are introduced animals, it is a case of native species suffering while an exotic prospers. Particularly handicapped are desert bighorn sheep. Wherever the range of the bighorn has been invaded by considerable numbers of burros, the bighorn has yielded. Domestic livestock also feel the press of burro competition in some areas.

The number of burros present today is considerably less than it was a few decades ago, mainly as a result of persistent shooting and trapping by stockmen and government range and wildlife managers. Partially as a result of an abortive attempt to encourage "no-closed-season" hunting of burros in California, that state now has a law that provides almost complete protection for feral burros. No other state recognizes burros in their game laws.

Various plans have been advanced for the management of the burros: (1) extermination, (2) complete protection, (3) classification as a game animal, (4) establishment of a burro sanctuary. None of these is satisfactory in itself; some sort of compromise is necessary.

The writer recommends nine steps to provide for more satisfactory burro management.

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BEAVER-FOREST RELATIONSHIPS IN ST. TAMMANY PARISH, LOUISIANA[1]

Robert H. Chabreck

Louisiana Wild Life and Fisheries Commission, Abbeville, Louisiana

Although much has been written about the ecology of beaver (*Castor canadensis*) in the northern and western United States, little has been published on the environmental relationships of this animal in the South. An investigation of beaver in St. Tammany Parish, Louisiana, in 1956 revealed differences in food and feeding habits as well as manner of living. This paper reports the results of the investigation with emphasis on the effects of beaver on the timber resources to which they had access.

Historical records indicate that beaver were common throughout much of Louisiana, but, as elsewhere, settlement of the state brought a drastic decline in the population, so that in 1928 Arthur (1931) stated that they were restricted to a few colonies along the Amite River, where local residents prevented their extirpation. With rigid protection this remnant population increased and by 1938, according to Dahlen (1939), it was necessary to remove beaver in areas where agricultural damage became serious. Some of these live-trapped beaver were released in St. Tammany Parish in southeastern Louisiana.

This parish borders the northern shore of Lake Pontchartrain and has four characteristic plant and physiographic divisions: subdelta marshes, hardwood bottoms, flat piney woods, and pine hills. The subdelta marshes lie in the southeastern part of the parish, adjacent to Lake Pontchartrain and vary in width from one to two miles. The hardwood bottoms are located in the southwestern part of the parish along Lake Pontchartrain and in the floodplain of most streams. The flat piney woods cover a large portion of the

[1] The author is indebted to Leslie L. Glasgow, School of Forestry, Louisiana State University, for his help in setting up the study and in preparation of the manuscript. Special thanks are also extended to Bryant A. Bateman, Louisiana State University, for many helpful suggestions.

parish and are located on the prairie terrace, which is characterized by much clay near the surface and rather poor subsurface drainage. The pine hills are situated on a second terrace in the northwestern corner of the parish.

METHODS

Areas with heavy beaver cutting and a large number of trees and shrubs were selected for sampling to determine the use of woody plants by beaver. Sampling was done along 5 bayous on plots that were 0.5-chain deep and 4 or 5 chains in length. Within each plot, all woody plants 1 inch or larger in diameter (measured 4.5 feet from the ground) were tallied by species and diameter class. The cruise also included the tallying by diameter class and species of "felled plants," as well as those that were "barked." The term "barked" was used to indicate the trees on which beaver had gnawed but which remained standing.

The sample plots contained 38 woody species, with an average of 1,349 stems per acre. Of the species of woody plants that occurred on the sample plots, 22 species had been utilized by beaver. These 22 species were classified according to utilization and value to beaver (Table 1). Utilization ratings were expressed in percentages. As an example, if there were 200 stems of a particular plant species present and 50 of them had been cut or barked by beaver, the percentage of utilization for that species was 25. A similar calculation was made for each species and the results of all calculations were listed from highest to lowest. The species showing a high percentage of utilization were believed to be preferred by beaver. Although utilization ranking may indicate a preference shown by beaver, it is not believed to be a good index of the value of the species to the animals; therefore, calculations were made to determine the value of each species. This was accomplished by multiplying the percentage that each species made up of the total stand, by the percentage to which that species was utilized. The results of these calculations were then ranked from highest to lowest. By this method, species making up a large portion of the stand but low in utilization received a rating that was approximately equivalent to species that had been utilized heavily but had comprised a small portion of the stand.

All plants used by beaver were then classified as high, medium, or low for both utilization and value on a basis of these calculations. For utilization, a plant species having more than 50 per cent of its total number utilized was listed as high, 10 per cent to 50 per cent medium, and less than 10 per cent low. In classifying the plants according to their value to beaver, all multiplications showing a product over 100 were listed as high, 20 to 100 medium, and less than 20 low.

OBSERVATIONS AND RESULTS

Beaver had cut or barked 42 per cent of these woody plants. As determined by analysis of variance, there seemed to be no selectivity by the animals for certain-sized diameter classes. Beaver had cut down 18 per cent of all woody stems present, of which over half were in the 1-inch class and none were over 5 inches in diameter. An additional 24 per cent of the woody plants 1 inch or more in diameter had been barked.

The most important species was loblolly pine, which made up 33 per cent of the plants on the sample plots and 58 per cent of the woody plants used by beaver. However, loblolly pine was preceded in utilization by sweetgum, southern sweetbay, and spruce pine, but these species combined made up only 12 per cent of the plants on the sample plots. Thigpen (1950) indicated that sweetgum, loblolly pine, and spruce pine were used heavily by beaver in St. Helena and East Feliciana parishes. Although silverbell was used very little in St. Tammany Parish, the writer observed areas in nearby parishes where silverbell made up a large portion of the beaver's diet. Casual observations throughout southeastern Louisiana and southern Mississippi indicate that spruce pine and sweetgum are cut heavily for food wherever beaver come in contact with them. Studies in the North-

TABLE 1.—WOODY PLANTS USED BY BEAVER IN ST. TAMMANY PARISH, LOUISIANA, 1956

Species[1]	Percentage of Plants Available	Percentage Utilized	Value Index	Utilization	Value
Loblolly pine *Pinus taeda*	32.7	71.7	2345	high	high
Sweetgum *Liquidambar styraciflua*	5.2	83.3	433	high	high
Spruce pine *Pinus glabra*	4.3	74.1	391	high	high
Southern sweetbay *Magnolia virginiana*	2.2	79.3	174	high	high
Tupelo gum *Nyssa aquatica*	2.6	54.5	142	high	high
Baldcypress *Taxodium distichum*	5.6	50.0	280	high	high
Bluebeech *Carpinus caroliniana*	1.3	66.7	87	high	medium
Buttonbush *Cephalanthus occidentalis*	4.5	22.8	103	medium	high
Water ash *Fraxinus caroliniana*	4.6	17.7	81	medium	medium
Southern red oak *Quercus falcata*	0.4	50.0	20	medium	medium
Black willow *Salix nigra*	1.1	20.0	22	medium	medium
Winged sumac *Rhus copallina*	0.4	50.0	20	medium	medium
Obtusa oak *Quercus obtusa*	1.5	30.0	45	medium	medium
Snowbell *Styrax* sp.	1.4	31.6	44	medium	medium
Cow oak *Quercus prinus*	0.7	20.0	14	medium	low
Mayhaw *Crataegus opaca*	0.2	50.0	10	medium	low
Waxmyrtle *Myrica cerifera*	8.0	8.2	66	low	medium
Black gum *Nyssa sylvatica*	5.4	2.7	15	low	low
Silverbell *Halesia diptera*	0.7	8.5	6	low	low
Water oak *Quercus nigra*	1.0	6.0	6	low	low
Titi *Cyrilla racemiflora*	2.2	3.4	7	low	low
Red maple *Acer rubrum*	1.7	4.3	7	low	low

[1] Plant nomenclature from Brown (1945).

ern and Western States have shown that, although beaver may cut pine for use in dam and lodge building, they do not normally use it for food (Seton, 1909:447–479; and Arthur, *op. cit.*).

Observations indicated that during the summer months beaver fed heavily on the roots and basal portions of herbaceous plants. Rice cutgrass (*Leersia oryzoides*) seemed to be a favorite food. Sawgrass (*Cladium jamaicense*), white waterlily (*Castalia odorata*), bulltongue (*Sagittaria* sp.), cattail (*Typha* sp.), pickerel weed (*Pontederia cordata*), and giant bullwhip (*Scirpus californicus*) were also eaten. An analysis of several beaver droppings in June

disclosed the presence of many undigested white waterlily seeds. Thigpen (*op. cit.*) reported that golden club (*Orontium aquaticum*) was utilized heavily by beaver in St. Helena Parish.

Beaver colonies were observed on 11 bayous. Since most of the bayous contained permanent, deep water, dams were built at only 3 colonies. Bank burrows were used on most bayous, but lodges were built where high banks were absent or where deep flooding was frequent. One colony was found in a small marsh. Within this marsh a series of canals, two lodges, and a dam had been constructed. The dam was 1,391 feet long and built of mud and marsh plants, but contained practically no wood.

DISCUSSION

In most areas, fewer woody plants were felled than were barked. Since few dams or lodges were built, very little woody material was needed for construction. Streams in Louisiana do not freeze over; consequently there was no need for the storage of winter food. Southern beaver feed much more extensively on land than those in northern states. Many standing trees were observed from which beaver had removed in excess of 12 square feet of bark from the basal surface of the stem.

The actual felling of plants was of little significance to forestry, since only small, suppressed trees or shrubs were cut down. This amounted to nothing more than a light precommercial thinning in most areas. However, I consider the cutting of ornamental plants of any type about residential areas to be detrimental. Phares (1950) reported that 88 per cent of the hardwoods cut by beaver in southwestern Mississippi sprouted back with increased vigor.

Beaver barked 24 per cent of all woody plants one inch or larger in diameter. Whenever a beaver gnawed on a tree, the effort was seldom so persistent that the tree was girdled; consequently, few trees died as a result of bark removal. Beaver girdled less than 3 per cent of the trees and less than one-half of this number died. Evidently bark removal had very little effect on tree-diameter growth. Increment borings on barked and comparable nonbarked loblolly pine trees revealed that growth was directly proportional to crown size. Trees with the fastest growth rate often had the greatest amount of bark removed. This may indicate that beaver selected the faster-growing trees.

Beaver scars on hardwoods permitted the entrance of wood-decaying fungi. Decay introduced by this method developed in a pattern similar to that for decay in hardwoods following a fire. Toole and McKnight (1955) found that the size of fire scars determined the rate and progress of the decay. Decay traveled fastest in scars extending more than one-fifth of the way around the tree. The decay moved through the sapwood at a fairly slow rate and usually reached the heartwood by the fourth year, but, once in the heartwood, decay traveled faster and moved upward at the rate of 1.3 feet in 10 years. It was not uncommon for beaver to cut into the heartwood, hence speeding the rate of decomposition. Toole and McKnight also stated that scars smaller than 2 inches usually healed before decay was initiated, but scars of greater width probably admitted fungi that eventually destroyed the valuable butt log. Eighteen per cent of the hardwoods of merchantable species received beaver scars that were presumably large enough for the introduction of decay.

A large number of loblolly pines at one colony had been attacked by black turpentine beetles (*Dendroctonus terebrans*). From external appearances, I believe that the beetles entered the trees through the beaver-scarred area. Bennett (1956) reported that adult beetles are attracted by fresh resin or skinned bark and that high populations may build up in fresh stumps or injured trees and spread to healthy trees nearby. These beetles usually prefer trees growing on wet or poorly drained sites or those along streams. Since the trees barked by beaver usually occupied such sites, conditions were ideal for an attack by black turpentine beetles.

Pine trees, when barked by beaver, accumulated a thick deposit of gum over the

scarred area. Since this resin is combustible, considerable damage resulted when a fire burned through a beaver-scarred loblolly pine stand. The pines that had been barked were heavily damaged, while adjacent unbarked pines were not injured.

Water impounded behind beaver dams sometimes floods and kills timber. The greatest damage of this type in St. Tammany Parish was found at a site where 4.5 acres of land had been flooded. A thorough investigation showed that 6.9 cords of pine less than 10 inches in diameter and 20,674 board feet (international one-quarter log rule) of pine over 10 inches in diameter had been killed. In addition, sweetgum, black gum, and tupelo gum were killed. Since beaver in this area do not build dams very often, damage of this type is uncommon.

When beaver do extensive property damage, certain control measures are often necessary. For many years all beaver control in Louisiana was done by the state, and troublesome beaver were removed on requests from landowners. The animals were live-trapped and used for restocking in areas that afforded a suitable habitat, but had no beaver present. As the beaver population increased, requests for removal became more and more numerous. In January 1956, a 30-day trapping season was allowed on beaver in 8 southeastern Louisiana parishes with hopes that troublesome beaver colonies would be controlled. Because of the low value of pelts ($4 to $6) and inexperience in trapping and pelt preparation, few beaver trappers finished the season (Smith, 1956). The total season's catch was very small, and it was necessary for the state to continue with its beaver-control program.

In view of the severe damage that beaver are capable of causing, it is advisable to use extreme caution with beaver restocking in areas similar to this, where the value of pelts scarcely justifies public trapping. Removal of animals by the state is a costly and difficult task.

SUMMARY

An investigation of beaver was made in St. Tammany Parish, Louisiana, in 1956. On plots sampled, sweetgum, sweetbay, spruce pine, and loblolly pine received heaviest utilization and were believed to be of greatest value to beaver. Of all plants present, beaver barked 24 per cent and felled 18 per cent. The woody plants felled were very small and of little significance to forestry. Pines barked by beaver were more vulnerable to an attack by insects, and increased the hazard of fire damage. Most hardwoods, when barked, became susceptible to the introduction of decay. Water impounded behind a beaver dam had killed 20,674 board feet of merchantable pine timber.

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MOBILITY OF MISSOURI DEER AND THEIR HARASSMENT BY DOGS[1]

Donald R. Progulske and Thomas S. Baskett

Entomology–Zoology Department, South Dakota State College, Brookings; and Missouri Cooperative Wildlife Research Unit, University of Missouri, Columbia, Missouri

There is little information on the mobility of the white-tailed deer (*Odocoileus virginianus*) in the middle United States; data are equally limited on the mobility of whitetails on land that is primarily agricultural or where there is yearlong harassment by dogs. The present study was made under all those conditions. It was based principally upon repeated observations of individually marked deer rather than upon kill records of tagged animals, which have often been the principal source of movement data for deer.

The study was carried out on the University of Missouri's Ashland Wildlife Research Refuge in Boone County and on adjacent private farmland. Most of the 2,240-acre refuge is forested with second-growth oak and hickory. Few stands of mature timber are found, but mast-producing trees are abundant. Large, bottomland corn fields are nearby, and small, ridge-top openings are planted to crops or are in various stages of old-field succession. The deer population in this locality probably did not exceed 20 per square mile during the study. Snow was never deep, and the deer did not yard. The period of intensive study was September 1952 to May 1956, but some data were gathered as early as March 1951, and as late as November 1957.

Deer were captured in modified Stephenson-type traps baited with ear corn and stock salt. Although trapping was carried on intermittently throughout the year, most of it was done during the winter and spring. The animals were marked individually in various ways. All except those recognized by distinctive antler shapes or other natural markings were tagged with plastic discs that were attached to the ears with button-type stock tags. Several ear-tagged deer were also marked with small bells attached to dog collars or with wide, colored collars, as described by Progulske (1957).

Searches for marked deer were made by varied methods: on foot, from a tower, blind, automobile, small airplane, and by trailing in the snow; a few records were obtained from hunting recoveries. Although there is probably some bias in favor of the more sedentary deer, deliberate attempts were made to avoid this by varying methods, routes, and times, and by frequent searches for marked deer several miles from any trap.

One hundred ninety-four records of movement were obtained for 31 deer identified by the markings described above. These included 17 recognizable adult bucks, 11 adult does, and 3 fawns. Nine other deer were tagged but not seen again. An adult doe, tagged in November 1954, was shot in November 1957; this 36-month span was the longest for any of the marked deer. The greatest number of records for any one animal was 30; this number was obtained both for a doe shot 19 months after being tagged, and for a buck last seen 6 months after being marked.

Movements

All Seasons

For all deer yielding suitable records, maximum distances moved were determined simply by measuring on maps the distances

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TABLE 1.—MOVEMENTS OF MARKED DEER DURING VARIOUS SEASONS

No. of Obs.	Max. Dist. Moved (Mi.)	Area Encompassed (Acres)	Period of Observation
ADULT FEMALES			
2	0[1]	—	Feb. 4–16, '53
2	0.3	—	Feb. 10–18, '53
2	0.6	—	July 10, '54–Feb. 21, '55
2	0.7	—	Jan. 28–Feb. 25, '52
3	0.2	10	June 20–Sept. 26, '54
3	0.7	70	Apr. 10–Oct. 7, '54
4	5.3	240	Nov. 12, '54–Nov. 5., '57
5	1.4	120	Mar. 16, '54–Apr. 13, '55
9	2.1	280	Mar. 21–May 1, '51
14	3.5	1610	Apr. 7–Nov. 7, '54
30	1.9	1000	Apr. 5, '54–Nov. 2, '55
FAWN FEMALE			
5	1.9	180	Aug. 15–Nov. 2, '55
FAWN MALES			
2	0.3	—	Sept. 3–Dec. 20, '55
3	0.9	60	Aug. 1, '55–Jan. 4, '56
Averages	1.4	400	
ADULT MALES			
2	0.1	—	Sept. 6–13, '55
2	0.2	—	May 24–July 7, '55
2	0.6	—	Sept. 14–Oct. 9, '55
2	0.7	—	Apr. 18, '52–Nov. 5, '54
2	1.0	—	Dec. 12, '55–Feb. 1, '56
2	5.3	—	Apr. 2–Nov. 6, '53
3	0.5	30	Jan. 26, '52–June 24, '53
3	0.7	30	Apr. 17, '54–Mar. 1, '55
3	1.2	50	Feb. 3, '53–Nov. 6, '54
3	1.3	190	June 9–Sept. ?, '55
3	1.9	280	June 21–Sept. 15, '54
5	0.6	30	Feb. 22–June 23, '54
6	2.4	580	June 30, '55–Oct. 31, '56
6	2.0	190	Feb. 19–Nov. 3, '54
8	9.3	6660	July 14–Oct. 27, '55
26	2.8	1920	Mar. 19–Nov. 6, '55
30	1.0	360	Mar. 28–Sept. 29, '55
Averages	1.9	940	

[1] Retrapped at tagging site.

between the two most widely separated points of observation, regardless of season. Pooled movement data for all adults and young fawns are shown in Table 1. For all deer, the average maximum distance moved was 1.7 miles.

Areal measure of movement was obtained for deer observed three times or more by connecting the outermost points of observation on maps, and measuring the areas of the encompassing polygons. Results of this analysis are also shown in Table 1. These areas varied from 10 acres for a deer observed only three times, to 6,660 acres for one observed eight times. The average area encompassed for all deer having applicable records was 695 acres, or more than one square mile.

Areas computed in this same fashion were termed "minimum home ranges" by Mohr (1947) in his work with small mammals. In the case of our pooled data for all seasons, the areas have some value as indicators of mobility, but they are not good measures of home ranges, because seasonal shifting and perhaps some temporary excursions from home ranges are included.

The fact that maximum distances moved by females (and fawns of both sexes) averaged 1.4 miles, while those moved by males averaged 1.9 miles (Table 1), suggests that bucks were more mobile than does. This indication is in accordance with the findings of other studies (Olson, 1938; Dasmann and Taber, 1956), but our own data are not conclusive because (1) there was great variability in the extent of movement of both males and females, (2) the most sedentary animal for which we had numerous records was a male, and (3) some females as well as males were observed several miles from the trapping sites. It is was not possible in this study to determine the effects of the rut upon mobility of deer of either sex.

Spring and Summer

The most precise information on movements was obtained in spring, summer, and early fall. During these periods, several deer seemed to have rather small and distinct home ranges in which they could be found repeatedly. This pattern was well illustrated by one male which was observed 30 times during the 6-month period from March to September 1955. The deer was always seen within the same 360-acre area, despite the fact that other parts of the refuge were watched continuously (Fig. 1).

A similar pattern was noted for an adult female sighted 30 times. This deer was observed with twin fawns in an area smaller than ½ square mile during two consecutive

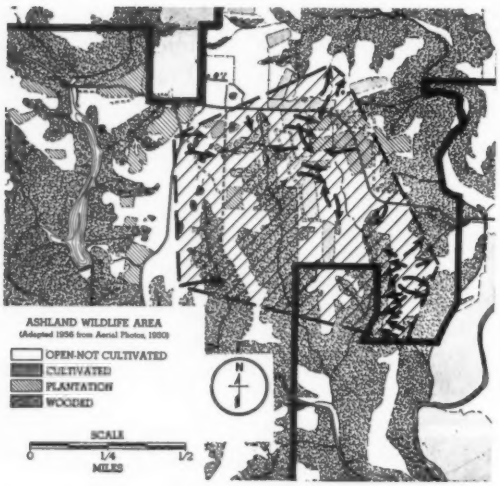

FIG. 1. Home range of a yearling male observed 30 times from March 28 to September 29, 1955.

spring and summer periods; this composite area is shown in Fig. 2. In the first period (1954) she was seen five times within an area of 310 acres and in the second (1955) she was observed 22 times within an area of 280 acres (disregarding two points that we interpret as temporary departures). The latter area lay almost completely within the former.

Movement data for marked deer during spring and summer are summarized in Table 2. The average maximum distance moved by males was 1.5 miles and the areas encompassed by points of observation averaged 630 acres. Corresponding figures for females were 0.8 mile and 170 acres.

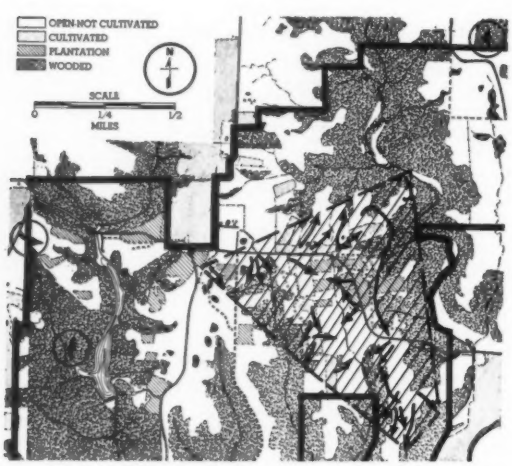

FIG. 2. Composite home range of an adult female observed 30 times during two spring and summer seasons.

TABLE 2.—MOVEMENTS OF MARKED DEER DURING SPRING AND SUMMER

No. of Obs.	Max. Dist. Moved (Mi.)	Area Encompassed (Acres)	Period of Observation
ADULT FEMALES			
2	0.3	—	Apr. 6–13, '55
2	0.5	—	Apr. 10–May 6, '54
2	0.6	—	Apr. 23–May 27, '54
3	0.2	10	Apr. 10–June ?, '54
5	1.3	310	Apr. 5–Sept. 25, '54
7	2.1	280	Apr. 8–May 1, '51
10	0.7	100	Apr. 7–July 6, '54
21	1.5	200	Apr. 8–Sept. 9, '55
FAWN FEMALE			
3	0.3	10	Aug. 15–Sept. 12, '55
Averages	0.8	170	
ADULT MALES			
2	0.1	—	Sept. 6–13, '55
2	0.1	—	Apr. 17–June 23, '54
2	0.2	—	May 24–July 7, '55
2	0.9	—	June 9–July 17, '54
3	1.2	170	Apr. 1–May 14, '54
3	1.9	280	June 21–Sept. 15, '54
4	0.5	20	Apr. 23–June 23, '54
4	8.0	1280	July 14–Sept. 3, '55
19	2.4	1640	Apr. 5–Aug. 23, '55
30	1.0	360	Mar. 28–Sept. 29, '55
Averages	1.5	630	

Seasonal Shifting

Sometime during fall, several of the deer disappeared from their spring and summer home ranges. A deer that apparently shifted areas seasonally was the adult female with a composite spring and summer range for two years which is shown in Fig. 2. Between November 6, 1954, and April 8, 1955, she was sighted only once (February 28) on the small spring–summer range, despite repeated searches. She was shot on November 2, 1955, approximately ½ mile from the nearest point in the known spring–summer range.

It may not be the rule for deer to return year after year to the same seasonal ranges.

An adult female marked in November 1954 was observed once within the month in the vicinity of the trap. She was not seen again until a year later, nearly 5 miles away. As far as could be determined, she did not return to the vicinity of the trap; she was shot in November 1957, approximately 1½ miles from the trap site.

Seasonal shifting of home ranges from the study area may have accounted for the progressive decline from late summer to January in total number of marked and unmarked deer observed (Fig. 3). This decline occurred in spite of improved conditions for observation; when deer were again seen in abundance, they were usually on their spring and summer ranges.

Fall and Winter

Movements of individually marked deer during fall and winter are summarized in Table 3. There were very few observations for this period, but the magnitudes of movement by deer of both sexes indicated are quite similar to those for spring and summer, as shown in Table 2.

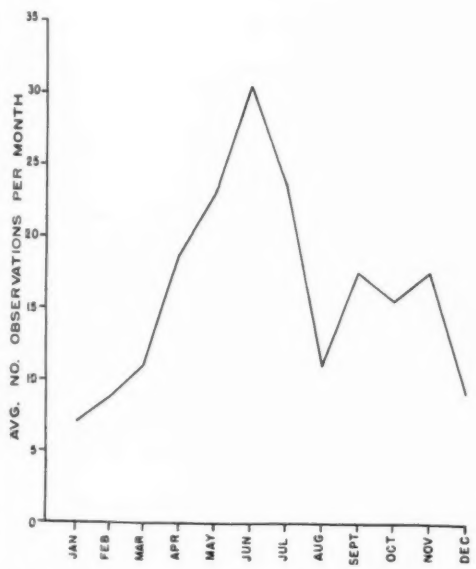

FIG. 3. Monthly trend in number of observations of deer from February 1954 to May 1956 (based on 444 observations).

TABLE 3.—MOVEMENTS OF MARKED DEER DURING FALL AND WINTER

No. of Obs.	Max. Dist. Moved (Mi.)	Area Encompassed (Acres)	Period of Observation
ADULT FEMALES			
2	—[1]	—	Feb. 4–16, '53
2	0.3	—	Feb. 10–18, '53
2	0.7	—	Jan. 28–Feb. 25, '52
2	0.5	—	Nov. 12–22, '54
3	0.9	100	Oct. 18, '54–Feb. 28, '55
4	2.9	360	Nov. 3–8, '54
FAWN FEMALE			
2	1.5	—	Oct. 27–Nov. 2, '55
FAWN MALE			
2	1.0	—	Dec. 31, '55–Jan. 4, '56
Average	1.0		
ADULT MALES			
2	0.1	—	Oct. 20–Nov. 6, '54
2	1.0	—	Dec. 22, '55–Feb. 1, '56
3	0.6	40	Mar. 19–27, '55
4	3.1	1410	Oct. 7–Nov. 6, '55
4	2.8	700	Oct. 20–27, '55
4	1.9	360	Oct. 28, '55–Feb. 1, '56
Averages	1.6	630	

[1] Retrapped at tagging site.

Movements of deer were also determined by tracking when snow cover was suitable. Snow often melted within a few hours, and opportunities for tracking were limited. However, two groups of deer were tracked for three days and several other groups for shorter periods. Some of the groups circled within small areas, while others made extensive movements. Fig. 4 shows the path followed by one group of four antlerless deer for three days following a snowstorm in March 1955. During this period the deer remained within an area of 275 acres, or less than ½ square mile. Fig. 5 shows the path taken by a group of five antlerless deer during a 3-day period; this path enclosed a much larger area of 1,440 acres, or 2¼ square miles. The deer were under little pressure from the observer, as indicated by their frequent bedding.

Extensive movement in winter by one male deer is depicted in Fig. 6. This deer traveled 2½ miles (straight-line distance) between 4 P.M. one day and 10 A.M. the next. It fed repeatedly during this time, indicating

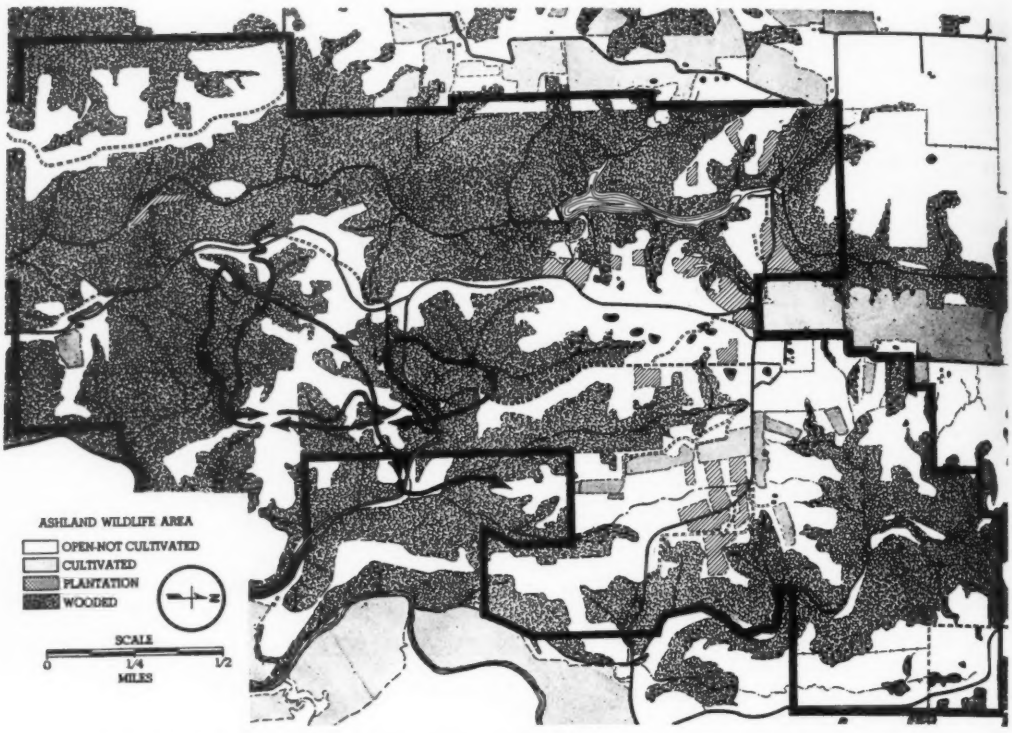

FIG. 4. Path followed by four antlerless deer tracked in snow, March 25–27, 1955.

that movement was little affected by the observer.

Although information derived by tracking was too fragmentary to justify generalizations about sizes of home ranges in winter, at least the deer movements shown in Figs. 5 and 6 involved much larger areas than those of the marked deer most frequently observed in spring and summer (Figs. 1 and 2).

Data somewhat similar to ours were furnished by Severinghaus and Tanck (1950), who mapped the paths followed by two wounded deer in New York; according to their maps, one deer circled repeatedly in an area of about 130 acres during a 6-hour period, and the other was tracked in an area of about 1,300 acres during a 2½-day period.

COMPARISON WITH OTHER STUDIES

The literature on movements of white-tailed deer has recently been reviewed in detail by Severinghaus and Cheatum (1956: 122–123, 152–158). From this review and other papers, the following seasonal pattern emerges.

The winter movements of white-tails are very restricted where yarding occurs (Kabat, Collias, and Guettinger, 1953; Dahlberg and Guettinger, 1956); where there is no yarding, movement may be more extensive (Skinner, 1929). Relatively little information is available on extent of movement in summer, but Townsend and Smith (1933) wrote that the deer they studied in New York remained within small areas during summer. Shifts from summer to winter range and vice versa are most pronounced where seasonal contrasts in weather are greatest, as in mountainous regions and across the northern United States and Canada (Severinghaus and Cheatum, *op. cit.*). Mobility may also be related to vegetative types inhabited and to age of the deer (Carlsen and Farmes, 1957).

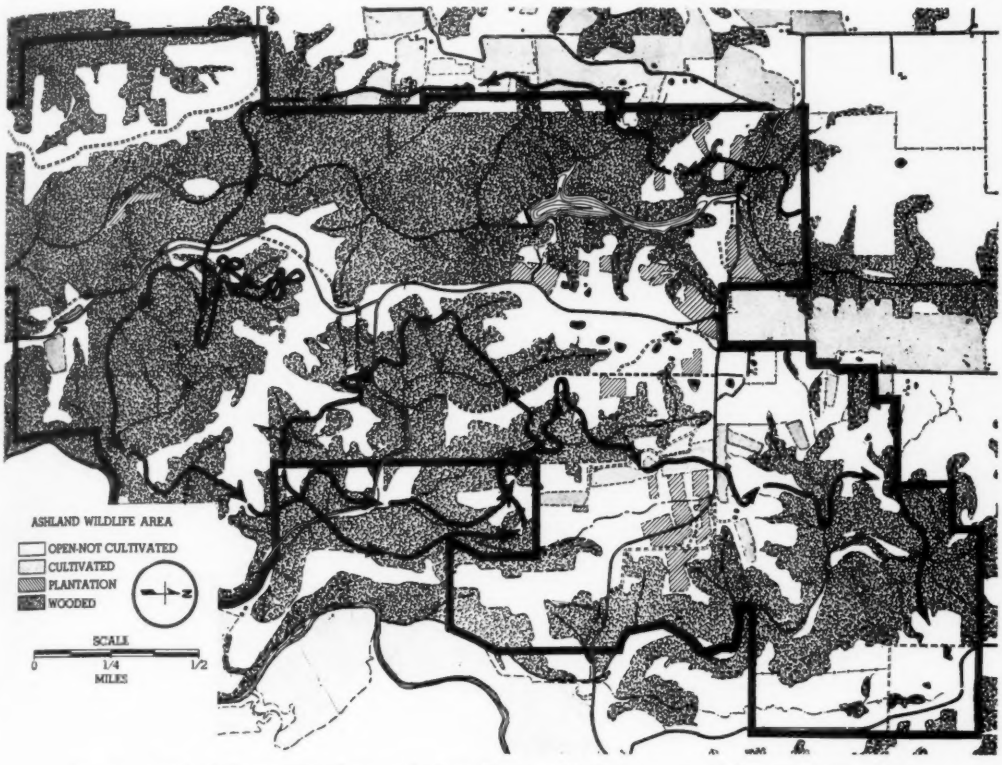

FIG. 5. Path followed by five antlerless deer tracked in snow, February 3–5, 1956.

Numerical data on movements of white-tailed deer as determined by studies of individually marked animals are summarized in Table 4, together with results of the present study. Since the Missouri study was based on wild deer released at the point of capture and observed during all seasons, data from studies based on movements made during a single season, or on transplanted deer, were not included in the table. Comparisons are difficult because of differing techniques of investigation and expressions of results. However, the amount of movement exhibited by the Missouri deer during all seasons seems more similar to that of Texas deer than to deer of the Lake States.

INFLUENCE OF DOGS

Under the conditions of this study, only hounds appeared to be of any consequence in harassment of deer, for most other breeds seemingly lacked the ability to remain on the trail of deer for long periods. Only on two occasions were dogs other than hounds found running deer on the study area. Although not all running hounds seen or heard were pursuing deer, records of total hound chases afford some measure of the harassment of deer at different periods. Monthly occurrences of 310 chases, noted from October 1954 through May 1956, are shown in Fig. 7. The greatest numbers occurred in November, December, and May. The November–December activities were apparently a result of the open season for raccoon hunting and weather favorable for fox hunting. A decrease in frequency of chases during January and February followed the closing of the raccoon season and accompanying unfavorable weather. During the spring denning period, mobility of foxes is reduced (Scott, 1943) and this, in turn, is considered to improve fox hunting. Presumably this improved hunting and the warmer spring weather resulted in an increased number of chases until a peak was

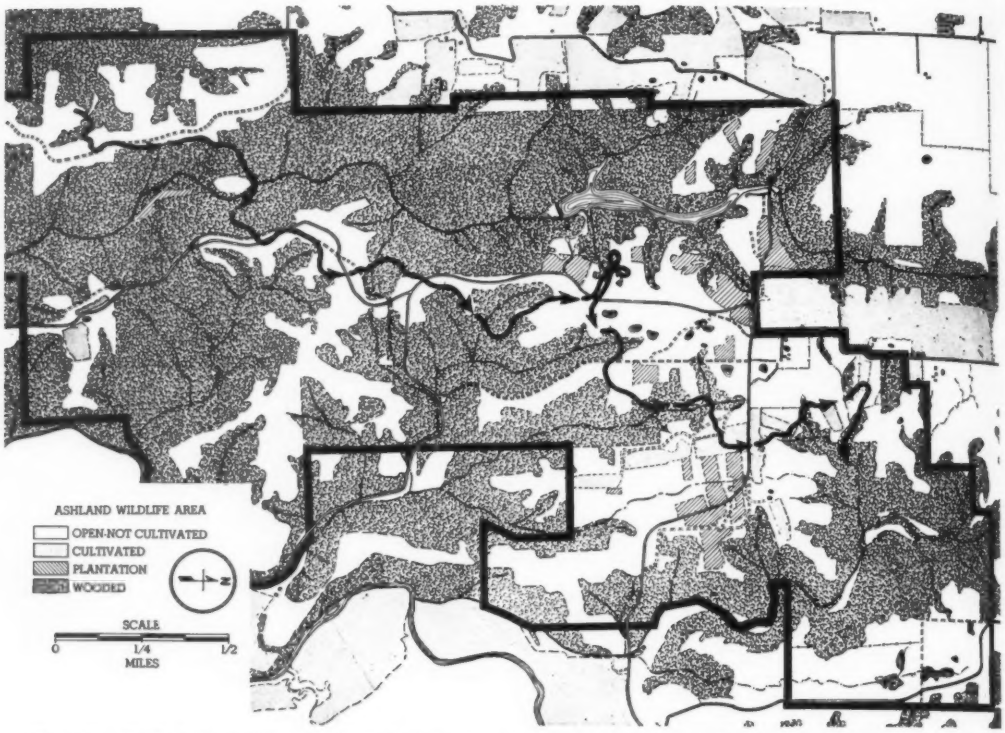

FIG. 6. Path followed by adult male between 4 P.M. February 1 and 10 A.M. February 2, 1956.

reached in May. As shown in Fig. 7, chases were of medium frequency during the peak of the fawning season.

The greatest average number of chases occurred on Saturdays, probably because many of the hounds were not free-running but were taken on week-end hunts by their owners. However, most dogs were locally owned. Ownership of 42 running hounds was determined from tags on the collars; they belonged to 27 different owners, most of whom lived within 5 miles of the refuge.

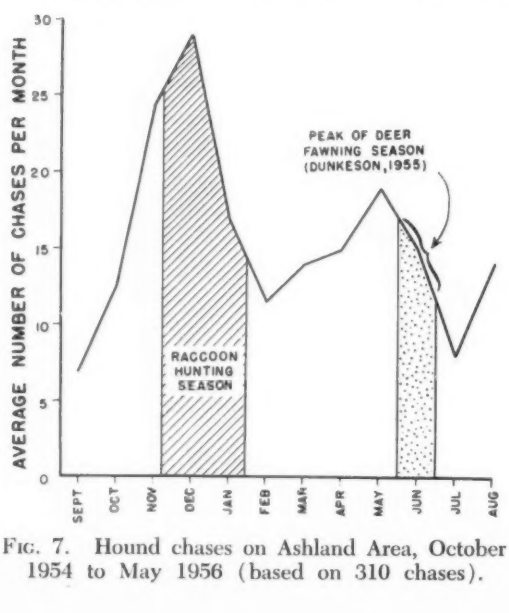

FIG. 7. Hound chases on Ashland Area, October 1954 to May 1956 (based on 310 chases).

Dasmann and Taber (*op. cit.*) stated that black-tailed deer (*Odocoileus hemionus*) could not be driven from their ranges, even by dogs. Under conditions of the present study, dogs apparently did make deer leave their home ranges, or at least move long distances. For example, the known route of one chase extended about 3¼ air-line miles; this probably represented only a fraction of the total distance covered by the deer. This distance was traversed in about ½ hour; there was no evidence that the deer circled.

In another case, hounds were heard chasing a belled male deer in the refuge. Within 15 minutes the trailing hounds were out of

TABLE 4.—MOVEMENT OF INDIVIDUALLY RECOGNIZABLE WHITE-TAILED DEER

Authority and Location	Means of Determining Extent of Movement	Number of Individually Recognizable Deer Shot or Observed	Extent of Movement
McBeath, 1941 (Michigan)	distance from traps (winter) to points at which shot (subsequent fall)	39 tagged deer	82 per cent shot within 16 mi.
Bartlett, 1950 (Michigan)	distance from traps (winter) to points at which shot (subsequent fall)	not stated	max. dist. 24 mi.; majority moved less than 15 mi.
Olson, 1938 (Minnesota)	Distance from winter yard to points at which shot (subsequent fall)	20 tagged deer	males: max. dist. 13 mi. avg. 5 mi. females: max. dist. 5 mi. most less than 1 mi.
Hunt and Mangus, 1954 (Minnesota)	distance from traps (winter) to points at which retrapped or killed (all seasons)	10 tagged deer shot or found dead; 21 retrapped; means of recovery of 2 not stated	max. dist. 45 mi.; 23 (70 per cent) in immediate vicinity of trap
Carlsen and Farmes, 1957 (Minnesota)	distance from traps (winter) to points where shot	63 tagged deer	males: max. dist. 22 mi. avg. 6.7 mi. females: max. dist. 10.8 mi. avg. 3.7 mi.
Dahlberg and Guettinger, 1956 (Wisconsin)	distance from traps (winter) to points at which killed accidentally or shot	35 tagged deer	avg. about 3.5 mi. from winter yard
This study (Missouri)	maximum distances moved based on data for all marked deer, regardless of seasons	192 observations, 30 marked deer	males: avg. max. dist. moved: 1.9 mi. females and fawns: avg. max. dist. moved: 1.4 mi.
Hahn, 1945 (Texas)	distance observed from trapping area in 9-month period	31 marked deer; no. of observations not stated	max. 1.5 mi.; most within 50–1,000 yards of trapping area
Hahn and Taylor, 1950 (Texas)	distance belled deer seen or heard from sq. mi. in which trapped; 20-month period	40 belled deer; 335 observations	85 per cent of observations within 1 mi. of sq. mi. where trapped

earshot, and had covered an air-line distance of nearly 1½ miles. The deer was seen again three days later, back in the refuge near the point of origin of the chase, and the animal was subsequently observed 16 times in this general vicinity. A more distant excursion was made by another male that was seen on the refuge on July 23, 1955, and again on September 3, within a few yards of the first site. Between these two dates, the deer was seen and positively identified at a point 7½ miles distant. It is not known whether dogs caused this excursion.

In Missouri, the deer regularly fled from the dogs, occasionally losing them by taking to water. In Dasmann and Taber's California study, deer often hid when pursued by dogs.

In our study, dogs were evidently the direct cause of few deaths of deer. Hounds were actually observed chasing deer on numerous occasions, and in nearly all instances were several hundred yards behind the fleeing deer. In a 6½-year period, there were only three reports that dogs had killed deer on or near the study area, and one of these reports was questionable. The effects of the continued harassment of the deer by hounds may have been more serious, but could not be evaluated. Since ownership

of most of the hounds was definite, this was not a problem of packs of free-running stray dogs that may cause heavy deer mortality in the Missouri Ozarks (Bennitt and Nagel, 1937) and in other states (Shaw and McLaughlin, 1951; Barick, 1953; Ward, 1954; and Brazda, 1957). It should also be emphasized that during our study there was no deep, crusted snow which might put the deer at a disadvantage.

SUMMARY

Maximum distances moved by 17 individually marked, male white-tailed deer averaged 1.9 miles; for 11 females and 3 fawns the average was 1.4 miles. Averages were based on 194 observations of marked deer, made during all seasons.

During spring, summer, and early fall, several deer had small, distinct home ranges in which they were seen repeatedly; these ranges were about ½ square mile in size for the two deer most frequently observed. Apparently there was some shifting of ranges in late fall. In winter, tracking showed that an area as large as 2¼ square miles was used by a group of deer.

Hounds harassed the deer at all seasons and sometimes drove them long distances; ultimate effects of this steady harassment could not be evaluated. Dogs seemingly were negligible causes of direct mortality of deer under the conditions of this study.

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PELLET-GROUP COUNTS FOR DEER CENSUS AND RANGE-USE INDEX

Glenn Rogers, Odell Julander, and W. Leslie Robinette

Colorado Department of Game and Fish, Grand Junction, Colo., Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, Utah, and U.S. Fish and Wildlife Service, Salt Lake City, Utah, respectively

Since the original study by Bennett, English, and McCain (1940), wildlife workers have displayed increasing interest in pellet-group counts both as a census technique for deer and as an index of deer use of the range. The purpose of this study is to increase the reliability of pellet-group counts as an index to deer populations and to deer use of range, and to investigate the problems of sampling pellet groups.

Effective translation of pellet-group counts into tangible information largely depends upon reliable knowledge of defecation rate for deer. Several reports indicate that the defecation rate may not be a constant. Eberhardt and Van Etten (1956) reported a statistically significant difference (at the 1 per cent level) in the winter defecation rate for white-tailed deer (*Odocoileus virginianus*) by age (fawns vs. older deer) and by diet. Dasmann and Taber (1955) concluded that the defecation rate for Columbian black-tailed deer (*Odocoileus hemionus columbianus*) on their study area in California must vary seasonally, the variation apparently being attributable to changes in the diet and character of the forage. Longhurst (1954) reported an increased defecation rate for domestic sheep when placed on green forage—from 13.3 to 15.5 groups per day. E. A. Hewitt of Iowa State College states (letter of November 18, 1955) that for livestock: "There is a very definite correlation with a decrease or increase in the amount of forage consumed upon the defecation rate. . . . Cattle usually defecate 10 to 24 times daily—more frequently if the food contains more water as in the case of succulent pasture." In addition, Eberhardt (letter of January 8, 1957) reports differences in the defecation rate for individual deer apart from age and diet.

In the western United States, pellet-group counts usually are made on winter ranges of migratory deer. Deer occupy these ranges for variable periods, but in Colorado, Utah, Nevada, and portions of neighboring states, the period of use commonly extends from December into April. Since no data about defecation rate covering this December–April period have been published, and since other factors mentioned above are also involved, additional study seemed desirable.

Thus, when the Colorado Department of Game and Fish constructed some deer-tight pastures on winter deer range to study forage competition between deer and livestock, the authors availed themselves of the opportunity to determine the defecation rate for Rocky Mountain mule deer (*Odocoileus h. hemionus*) as an average for the entire wintering period. This paper reports the co-operative study conducted in these pastures from 1951 to 1955.

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Description of the Study Area

In 1947 the Colorado Department of Game and Fish started construction of a series of deer-tight contiguous pastures, varying from 90 to 190 acres each, at the

Little Hills Experiment Station in northwestern Colorado.

The pasture area consists of a series of parallel draws from one-quarter to one-half mile apart; they all drain in a northerly direction. The elevational difference between the draws and adjacent ridges is as much as 300 feet.

From 3 to 40 deer were placed in each of 2 to 4 pastures each fall or early winter. They were removed the following spring, so that workers could derive carrying-capacity figures and could study the influence of different stocking rates upon the range.

Pastures were stocked in the fall by driving wild deer into narrow lanes leading to the pasture gates. These lanes were sections of deer-tight fence, 8 feet high and 50 feet to 250 feet long, parallel to the pasture fence. Wings were extended from the open ends of the lanes to assist in funneling deer into the pastures. Gates to the lanes and the pastures could be closed remotely by using long trip wires. If the quota of deer could not be obtained in the above manner, additional animals were trapped and brought in from other areas. The deer were removed each spring through organized drives; an observer stood near each gate to record the number of escaping deer. Animals that could not be removed in this manner were shot.

A few deer died each winter within the pastures, and a few animals either escaped or entered from the outside, so that precise figures for deer-days' use are accordingly available for only one pasture (Pasture 6 in 1953). However, periodic winter patrolling around and within the pastures reduced the possible error in determining deer-days' use, so that the maximum and minimum possible number of deer days varied only an average of plus or minus 5 per cent from the "probable" number for 15 different pasture-stocking values. Fawns comprised about 40 per cent of the deer for which age records were obtained (74 adults and 50 fawns). This percentage exceeds but slightly the proportion of fawns found in many wild mule deer herds.

A good variety of forage was available to deer in these pastures. Browse species included serviceberry (*Amelanchier utahensis*), true mountain-mahogany (*Cercocarpus montanus*), bitterbrush (*Purshia tridentata*), big and little rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*), big sagebrush (*Artemisia tridentata*), Gambel oak (*Quercus gambelii*), pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), snowberry (*Symphoricarpos tetonensis*), and horsebrush (*Tetradymia canescens*). In addition, several species of forbs and grasses were available primarily during late March and April after new growth commenced but prior to pellet counting.

SAMPLING PROCEDURE

The pastures were sampled for five different years (1951 through 1955) in late April or early May after the snow had completely melted on the steep north exposures. New growth of grasses and forbs had started by this time but was not so dense as to interfere materially with pellet counting. Sampling intensity was determined chiefly by the number of participants and available time. Statistical analyses revealed that the sampling error for each pasture usually was within the desired objective of 10 per cent.

Sampling of the pastures was generally on a restricted random basis. Each pasture was divided roughly into three or four blocks, and from 3 to 14 line-plot transects (with the few exceptions noted below) were located at random within each block. Possibilities for transect locations were at l-chain (66-foot) intervals. Circular plots were spaced mechanically along the transect. During the first four years, 0.01-acre plots were used, but 100-square-foot (0.0023-acre) plots were used in 1955. Included in the 1952, 1953, and 1954 surveys were permanently marked plots that had been cleared of old pellet groups the previous summer. These plots, established initially for vegetal studies, were located on a grid pattern at 5-chain intervals. To include these plots meant that some of the transects for these years were mechanically spaced.

In 1955, Pasture 3 was substituted for Pasture 6, since it provided more accurate stocking records and also because it had not been stocked with deer during the past five years. It has been our observation, as well as Ferguson's (1955), that current-winter's groups can be distinguished quite readily from those of previous winters, provided the pellets are dry on the surface. In Pasture 3 and on the permanently marked and cleared plots, the possibility of counting old groups was negligible. These counts served as a check on other pastures where there was some likelihood of counting old pellet groups.

In 1952, two distinct surveys were made. The transects of the first survey were run in a north-south direction, whereas those of the second were in an east-west direction. Subsequent to 1952, two counts were made on each plot, one clockwise and the other counterclockwise, as insurance against missing groups.

In statistical analyses, the transect was the unit; and since the transects had different lengths, it was necessary to weight each according to the number of plots it contained. Since we were not interested in comparing blocks, block variances were pooled for each pasture.

RESULTS AND DISCUSSION

The average defecation rate (Table 1) for all samples was 15.21 pellet groups per deer day, with confidence limits of 14.15 to 16.27.

Defecation rates shown for 1951 and 1952, when only one count per plot was made, were increased by 3.2 per cent to account for pellet groups missed. This increase was based on counts in subsequent seasons and on work by Robinette under similar conditions in Utah. This value can by no means be considered a constant, for the proportion of pellet groups missed can vary with density and type of vegetation, color of soil, and individual making the count.

There is considerable variation in the defecation rates obtained by years for the different pastures. The greatest variation between pastures occurred in 1951 and 1953. A partial explanation for the 1951 variations could be that the pellet-group counting was a new technique to most of the participants. In 1953, several workers had difficulty in distinguishing current groups from older ones, because some of the pellets were wet from occasional showers during the counting period.

Other factors, a combination of which probably accounted for most of the variations in defecation rates, are as follows: (1) sampling errors as shown in Table 1 for duplicate surveys in 1952; (2) lack of precise stocking figures for all pastures except one; (3) differences in stocking rate from 4 to 38 deer days per acre; (4) differences between pastures in proportion of fawns to mature deer; (5) variation resulting from abnormally high or low defecation rates for individual deer in pastures stocked with 10 or fewer deer; and (6) differences in the proportion of time deer were on green herbaceous forage.

The very high defecation rate of 20 for Pasture 6 in 1953 might appear to confirm the suspicion that old wet groups could have been counted mistakenly for current ones, except for the fact that cleared plots also gave a defecation rate of 20. All of the factors listed above except #2 possibly could have contributed to this high defecation rate. However, the most likely causes appear to be: individual variation, since only 5 deer were in the pasture; a high percentage of adult deer (4 adults to 1 fawn); and a higher proportion of time spent on succulent spring forage in 1953 than for other years.

Our data tend to verify our belief that current pellet groups are distinguishable from older ones. The defecation rate obtained from an average of all of the pastures (15.21) agrees closely with that from cleared plots (14.87). Likewise, data from Pasture 3 for 1955, where there was virtually no chance of counting old groups, gave a higher rate (16.52) than the cleared plots.

Only two published defecation rates for deer under fence are known to the writers: (1) 12.7 derived by McCain (1948) from data by Rasmussen and Doman (1943) for

TABLE 1.—DEER PELLET-GROUP RECORDS FOR PASTURES AT LITTLE HILLS EXPERIMENT STATION[1]

Year	Pasture No.	No. of Plots: 100-sq. ft.	No. of Plots: 0.01-acre	No. of Pellet Groups	Computed Pellet Groups: Per Acre	Computed Pellet Groups: Per Pasture	Deer Days: Min.	Deer Days: Max.	Deer Days: Prob.	Computed Defecation Rate (Groups Per Day)	Stand. Error (Per Cent)
				ALL PLOTS							
1951	4	—	585	1,175	200.9	29,058	1,536	1,878	1,707	17.56	6.97
	6 & 7	—	850	1,076	126.6	24,130	1,475	1,958	1,956	12.82	5.87
1952											
(May 6)	4	—	337	475	140.9	20,394	1,401	1,429	1,415	14.87	8.55
(May 7)	4	—	242	322	133.1	19,252	1,408	1,436	1,422	13.97	14.83
(May 6)	6 & 7	—	468	692	147.9	28,190	1,767	1,959	1,840	15.81	6.95
(May 7)	6 & 7	—	341	427	125.2	23,863	1,773	1,965	1,846	13.34	6.85
1953	4	—	505	551	109.1	15,780	1,065	1,427	1,095	14.41	9.40
	6	—	345	316	91.6	9,154	446	446	446	20.52	7.13
	7	—	309	191	61.8	5,603	297	402	402	13.94	20.66
1954	4	—	510	1,650	323.5	46,791	2,971	3,192	3,130	14.95	4.99
	6	—	352	1,218	346.0	34,576	1,918	2,325	2,122	16.29	3.98
	7	—	312	410	131.4	11,914	702	870	770	15.47	16.04
1955	3	1,979	—	661	145.6	23,705	1,381	1,489	1,435	16.52	8.06
	4	2,017	—	2,491	538.0	77,816	5,258	5,614	5,457	14.26	4.23
	7	1,073	—	430	174.8	15,849	976	1,023	1,004	15.79	6.72
Total or average				12,085						15.21[2]	8.75
Confidence limits (95-per-cent fiducial interval)										14.15–16.27[3]	
				CLEARED PLOTS							
1952	4	—	52	70	134.6	19,469	—	—	1,415	14.20	3.22
	6 & 7	70	—	91	130.0	24,778	—	—	1,840	13.90	3.91
1953	4	52	—	47	90.4	13,075	—	—	1,095	11.94	5.01
	6	38	—	34	89.5	8,944	—	—	446	20.05	5.31
	7	32	—	16	50.0	4,534	—	—	402	11.28	10.38
1954	4	49	—	155	316.3	45,750	—	—	3,130	14.62	3.92
	6	38	—	134	352.6	35,235	—	—	2,122	16.60	3.83
	7	32	—	38	118.8	10,772	—	—	770	13.99	12.31
Total or average				585						14.87[2]	7.53
Confidence limits (95-per-cent fiducial interval)										12.13–17.61[3]	

[1] Pasture acreages are: Pasture 3–162.81; 4–144.64; 6–99.93; 7–90.67.

[2] The 1951 and 1952 values were increased by 3.2 per cent to compensate for groups probably missed (*see* text), and the final average computed by weighting each defecation value by the number of groups counted in the sample.

[3] Determined from variance of the computed defecation rates.

mule deer in a 741-acre pasture in central Utah for the months of August through October, and (2) 13.0 derived by Eberhardt and Van Etten (*op. cit.*) for penned white-tailed deer in winter in northern Michigan.

It seems noteworthy that these two rates should agree so closely, despite the fact that they were for different seasons, diets, and even species of deer. The defecation rate we have derived exceeds the foregoing by two full groups, or about 15 per cent.

Rasmussen and Doman's figures were obtained from Maple Springs deer pastures in Utah. This is typical winter deer range, and hence, hot and dry with little green forage available during August, September, and October, when the data were taken. The area was heavily overstocked, as shown by reports of severe overuse of forage. Stocking rate for the year was at least 80 deer days per acre (and during the previous year probably had been double this) in comparison to a rate of 4 to 38 deer days per acre for Little Hills pastures. This heavy overstocking at Maple Springs possibly could have caused a lowered forage intake

and defecation rate by deer. Also, deer here were forced to subsist largely on Gambel oak, which tends to produce constipation in livestock when taken in quantity (Marsh, 1929).

Computation of the monthly defecation rates from Rasmussen and Doman's (*op. cit.*) data gives a value of 11.12 for August, 13.08 for September, and 13.54 for October. The cause for this apparent upward trend is not known. It might reflect only sampling variation. However, the lowered monthly stocking rate (from 185 deer in August to 155 in October) and the availability of fallen leaves from deciduous shrubs [maple (*Acer glabrum*) and Gambel oak] in late September and in October may have increased the amount of food available per deer. Another possible explanation is that the current fawns were counted in determining deer days' use in August when many of these fawns (especially those born in late June and early July) were still nursing. It seems possible that a fawn receiving such a concentrated food as milk would defecate less frequently than one feeding strictly on forage. Also, the fecal groups from these young fawns may have been so small that some were missed in the August counts.

Eberhardt and Van Etten's (*op. cit.*) figures were obtained for penned white-tailed deer on various winter diets. Their highest rate, 14.6, was obtained for adult deer on the "cafeteria" diet, whereas the average was only 13. Van Etten, in a letter dated February 26, 1957, wrote in answer to our query:

> There is a very good reason for the higher rate of defecation for the "cafeteria" diet. This diet was the control for all others and consisted of eleven species: white cedar, balsam fir, white spruce, hemlock, red maple, sugar maple, white birch, yellow birch, black ash, red osier dogwood, and tag alder. Deer on this control or "cafeteria" diet received unlimited quantities of these foods. In contrast, all test deer were on limited quantities of generally poorer foods especially in the late winter when the pellet checks were made. The better foods were restricted . . . as winter progressed. Therefore, there is no question that the deer on the "cafeteria" diet received better nutrition and were in better physical condition than those on test diets. In some instances test deer were near the point of starvation.

The Little Hills deer had a diet possibly as satisfactory as the "cafeteria" diet of Eberhardt and Van Etten's (*ibid.*) Michigan deer. Furthermore, the fact that they obtained some new herbaceous forage for at least three to four weeks prior to pellet counting gives added reason for their higher defecation rate.

Variety appears to be important in determining the quality of forage consumed by deer (Van Etten, *op. cit.*; Davenport, 1939), and the amount of forage consumed appears in turn to influence the defecation rate (Hewitt, *op. cit.*). On the basis of our study, we recommend the use of 15 as the overwinter daily defecation rate for mule deer on moderately stocked juniper–sagebrush ranges offering a selection of several browse species. A value of 13 may be more accurate on depleted ranges or other areas where variety of forage species is very restricted.

SAMPLING INTENSITY

Game managers using the pellet-group census method frequently ask how intensively they should sample. This question unfortunately has no stock answer, for too many variables are involved. Four important variables are: (1) density and distribution of pellet groups, (2) distribution and size of sampling plots, (3) size of area to be sampled, and (4) sampling accuracy desired.

A brief discussion of the foregoing points will perhaps illustrate why, in the absence of preliminary survey data for the specific area involved, no definite answer can be given to the question of sampling intensity.

1) A linear regression of sampling intensity required for a 10-per-cent error and 68-per-cent confidence limits over deer days' use (reflected by pellet-group density) was computed for the Little Hills data. The results indicated that doubling the stocking rate from 10 to 20 deer days, for example, reduced the estimated area to be sampled by 70 per cent for the cleared-plot data and by 46 per cent for all plots. Actually, a regression involving these two variables would be curvilinear rather than linear, for in

practice the pellet-group density is never reached where no sampling is required. But the analysis does illustrate the principle that reduced sampling is required whenever increased density of pellet groups occurs. Likewise, reduced sampling is indicated when pellet-group distribution is relatively uniform.

2) A good sampling design often can increase the accuracy of survey results or reduce the area to be sampled. Variability of sampling results and hence a reduction in sampling required often can be achieved by running the line-plot transects in the direction of greatest variability in pellet-group distribution. The transects should traverse the winter deer range perpendicularly or diagonally to the contours rather than parallel to the contour.

Our data indicated that plot spacing may also be a factor in sampling efficiency. For example, data from the cleared plots, which were located on a grid pattern, indicated that a sampling intensity of 1.85 per cent was necessary (for a 10-per-cent error and 68-per-cent confidence limits), as opposed to 3.72 per cent for all plots where the plots along a transect were closer together than were the transects. There was some indication that the 100-square-foot plot was more efficient strictly from the standpoint of area sampled than the 0.01-acre plot.

3) Other things being equal, less sampling, percentagewise, is required for a large population than a small one. The studies at Little Hills covered relatively small range units of 90 to 160 acres. Sampling requirements, considered as a percentage of an area, should be much less on open range areas involving several thousand acres than for small pastures. The actual number of plots needed on open range may not differ greatly from that needed for large pastures since pastures, such as those at Little Hills, include most of the variation commonly found on larger areas of open range.

4) The degree of sampling accuracy desired is a matter to be decided by the game manager or researcher. Economics, availability of trained personnel and of time, and use to which the data will be put are important considerations in arriving at a decision. It is doubtful whether the game manager can devote the time necessary to achieve a 10-per-cent sampling error and 68-per-cent confidence limits in sampling results. Probably he must be content with a greater error or wider confidence limits, or both. Our work at Little Hills indicates that, for similar situations, from 13 to 19 line-plot transects of 25 plots each (or other-length transects containing a like number of plots) are needed to approach a 10-per-cent sampling error and 68-per-cent confidence limits when using 0.01-acre plots. For plots of 100-square-foot size, 12 to 23 line-plot transects of 40 plots each are needed.

SUMMARY

Results of five-seasons' deer pellet-group counts in deer-tight pastures at Little Hills Experiment Station, Colorado, indicated an overwinter daily defecation rate of about 15 groups for Rocky Mountain mule deer (*Odocoileus h. hemionus*). Pastures usually were moderately stocked and the number of deer days in each pasture was closely determined by direct stocking and removal of the animals. Recorded defecation rates varied between years, apparently as a result of observer experience, sampling errors, imprecise stocking data, variations in stocking rates and fawn ratios, individual deer differences in physiology, and variations in the time that deer were on green herbaceous forage. Counts on plots previously cleared of pellets agreed closely with those on uncleared plots. For depleted ranges and other areas lacking a variety of forage species, a value of 13 pellet groups per day may be more accurate. Sampling intensity should vary from one area to another according to four factors that are discussed.

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BRIEFER ARTICLES

SALMONELLOSIS (BACILLARY DYSENTERY) OF FUR SEALS

William L. Jellison and Kelsey C. Milner

U.S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana

For many years, excessive mortality among pups of the fur seal, *Callorhinus ursinus*, has been a major factor in the biology and management of fur seal herds of the Pribilof Islands. Over 72,000 fatalities have been observed on St. Paul Island alone in a single whelping season, and deaths may exceed 1,000 a day during the early summer. In regard to these deaths, Kenyon, Scheffer, and Chapman (1954) stated: "Now that the herd has reached its ceiling, the mortality rate has increased to about 14.6 per cent (average 1949–1951), and the mortality to a total of 60,000 to 80,000 pups per summer. The mortality rate may be as high as 39 per cent on individual rookeries. The majority of deaths are from hookworm disease." The hookworm involved is *Uncinaria lucasi* Stiles.

An intensive study of hookworm disease in these animals is being made by O. Wilford Olsen for the Fish and Wildlife Service, U.S. Department of the Interior, which manages the seal herds. At the invitation of the Fish and Wildlife Service, one of us (W. L. J.) had the opportunity to visit the Pribilof Islands from August 18 to September 15, 1951, and to work with Dr. Olsen on the hookworm problem and on other diseases and parasites of seals.

During the late summer, as pups mature, fatalities from hookworm infestations decrease, so that other causes of illness and death become more conspicuous. Some sick pups collected on the rookeries in late August and September had only moderate or light hookworm infestations that were considered to be insufficient to cause debility or death. These were examined for the presence of other disease agents.

Cultures were made from 12 pups, and *Salmonella enteritidis* (Gaertner) Castellani and Chalmers was isolated from five by direct culture of heart blood or by culture of tissue obtained at autopsy. Additional cultures were isolated from tissues of these same seals and from seal lice (Anoplura) brought in a frozen condition to the Rocky Mountain Laboratory. Tissues that had been preserved by freezing were also tested by trituration and injection into white mice. These mice regularly succumbed, and cultures of *S. enteritidis* were again isolated. Other pathogenic agents were not recovered by culture or animal inoculation. Lice combed from two sick pups were disinfected externally, washed in sterile saline, macerated, and cultured. Those from one pup yielded nothing of significance, but *S. enteritidis* was isolated from lice of the other.

Specimens of blood were collected from 22 seal pups, 3 yearling seals, and 5 northern sea lions (*Eumetopias jubata*). These included animals from which *S. enteritidis* was later isolated. Serums were tested by the macroscopic test-tube technique for agglutinins against *S. enteritidis* antigen, which had been prepared from a culture isolated from a seal. Only one serum, from a sick pup, gave significant agglutination, which was complete at a titer of 1 to 80, whereas all others failed to produce agglutination at dilutions of 1 to 20.

DISCUSSION

The role of hookworms as the cause of extensive mortality among seal pups is well established, and the importance of these parasites should not be minimized. Other known causes of death include starvation and mechanical injury. The isolation of *S. enteritidis* from a significant proportion of sick and dying pups examined late in the summer establishes another probable cause of death.

The excrement from thousands of fish-eating adult seals and their young, which inhabit the rookeries for 3 or 4 months, and their decomposing carcasses result in unsanitary conditions beyond accurate description. Persistent dampness from fog and light rain aggravates the situation. Rainfall is seldom sufficient to wash the beaches. Temperatures are low enough to prohibit rapid decomposition of organic matter. Only the rocks and beaches at intertidal zone are reasonably clean when exposed. These conditions, although "natural," are certainly conducive to the spread of enteric pathogens and parasites.

The significance of finding S. *enteritidis* in lice from a sick pup is not apparent. As reported by Jellison (1952), pups and adults are consistently infested with two distinct species of Anoplura, *Antarctophthirus callorhini* (Osborn) and *Prochinophthirus fluctus* (Ferris). The actual specimens found infected had been ground for testing and were not identified. They may have been either one or both of the above species of lice. Furthermore, the crowded condition of the rookeries would readily permit transfer of lice from dead to living seals. Salmonellosis is not usually considered to be an arthropod-borne disease. However, there is some evidence that lice may play an important part in the spread of *Salmonella* during human epidemics in prisons and concentration camps. The subject has been thoroughly reviewed by Milner, Jellison, and Smith (1957). In their experimental work, it was shown that human lice were readily infected with S. *enteritidis* but that transmission of the organism by bite was unlikely.

SUMMARY

Salmonella enteritidis was isolated from blood and viscera of 5 of 12 sick fur-seal pups, *Callorhinus ursinus*, collected on the Pribilof Islands during the late summer of 1951. Lice from one of the pups so examined also harbored S. *enteritidis*. Salmonellosis may contribute significantly to mortality of seal pups.

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MODIFICATIONS OF RUFFED GROUSE TRAPS[1]

Robert E. Chambers[2] and P. F. English

Department of Zoology and Entomology, The Pennsylvania State University, University Park, Pennsylvania

During the two-year period, 1954–56, field research on ruffed grouse (*Bonasa umbellus*) by the senior author indicated that certain modifications in the construction of the mirror trap and cloverleaf trap were desirable.

The mirror trap, which was first described by Tanner and Bowers (1948), has proved to be the most effective means of capturing adult male grouse. Since the site for this trap is dependent on the location chosen by a grouse for drumming, it was at times necessary to carry traps one-quarter to one-half mile from the road, often through heavy cover. The bulky nature of the original traps proved to be a hindrance to progress on foot, particularly when it was desired to carry more than one trap at a time. This same feature limited the number of traps that could be handled when it was necessary to transport traps in an automobile. Dorney and Mattison (1956) alleviated this problem by reducing over-all dimensions of the traps.

The cloverleaf trap, as applied by Liscinsky and Bailey (1955) for trapping grouse broods and woodcock (*Philohela minor*), consists of a central capturing cage from which extend two leads. The ends of these leads distant from the central cage were left unguarded. It was the senior author's belief that some grouse walked around these ends and avoided capture. Although it is possible that some of these birds may eventually have been trapped in the central cage, it does not seem probable that, once having passed these unguarded points, they would return along the lead in the opposite direction.

MIRROR TRAP

By devising a collapsible, folding frame, the transportation of this trap was greatly facilitated.

[1] A contribution of the Department of Zoology and Entomology, The Pennsylvania State University, University Park, Pennsylvania. Authorized for publication on July 23, 1957 as paper No. 2171 in the journal series of the Pennsylvania Agricultural Experiment Station.

[2] Present address: West Virginia Conservation Commission, Elkins, West Virginia. The authors extend thanks to Ward M. Sharp, Leader, The Pennsylvania Cooperative Wildlife Research Unit for advice in this project. Thanks are extended to Stephen A. Liscinsky of the Pennsylvania Game Commission for helpful suggestions regarding construction of the traps.

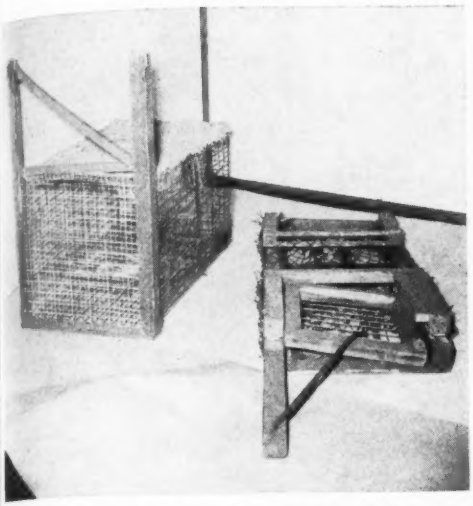

FIG. 1. Original mirror trap at left and modified trap in collapsed position.

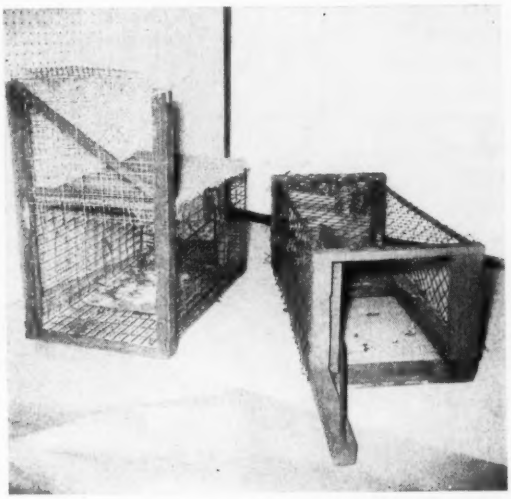

FIG. 2. Original mirror trap at left with modified version erected. Both in set position.

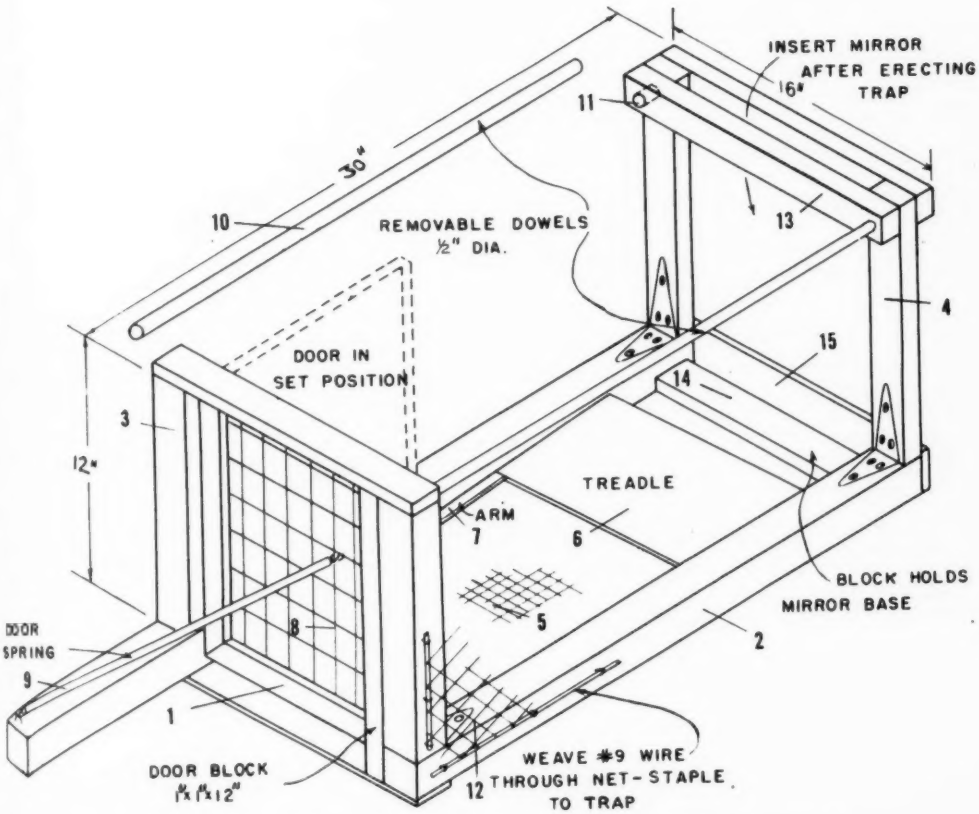

FIG. 3. Construction diagram of modified mirror trap. The numbers are explained in the text.

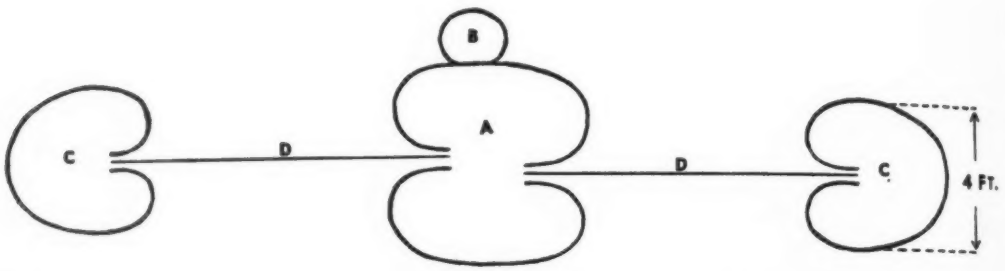

FIG. 4. Diagrammatic sketch of cloverleaf trap from above, showing central cage (A), holding cage (B), and end cages (C), and 30-foot leads (D).

It was a relatively simple matter to carry two or three of these traps in the collapsed position for considerable distances (Fig. 1). Fig. 2 shows the modified and the original model in the set position.

The use of 1-inch mesh, linen or cotton netting, instead of wire, to cover the trap provided an advantage in addition to collapsibility. Whereas grouse often literally scalped themselves in the wire traps, no evidence of such injury was ever observed on a bird captured in a trap made of netting.

The construction of the modified version of this trap (Fig. 3) is as follows. Since operation of the door (1) requires a sturdy frame, the base (2) and front uprights (3) are constructed of 2-inch-square lumber. The rear uprights (4) need not be as heavy. All four uprights are hinged to fall toward the center of the trap. The floor (5) is ¼-inch mesh hardware cloth. The treadle (6) is made of any thin wood that will permit the attachment of a wooden arm (7). When in the set position, the pressure of the door against the arm holds the treadle in place. The treadle arm must be of sufficient length to permit the door in closing to clear the body of the bird as it steps on the treadle. Welded wire having a 1-inch by 2-inch mesh (8) is stapled to the inside of the door frame. Attached to this is a common door spring (9), which pulls the door shut. The trap is erected by flexing the dowels (10) and inserting them into drilled holes ⅛-inch deep (11) at the top of the uprights. Tension of the netting (12) holds the dowels in place. The mirror is then dropped into position as indicated. It rests on the floor and is held at the top between the two cross braces (13) and at the bottom between a block (14) and a crosspiece (15) at the rear of the trap. Both dowels and the mirror are carried on the floor of the trap when it is collapsed.

Construction time is from four to six hours. Since most of the trap frame can be constructed from scrap material, construction cost should not exceed $1.75.

Trapping results indicated that the modified trap was as effective as the original version. Employing two of the modified traps and three of the original type, 11 male grouse were captured in April and May of 1955. Five were captured in the modified traps, which were set for a total of 20 trap-days. In 39 trap-days, six were captured in the original traps. Similar results were obtained during the spring of 1956, although only nine grouse were trapped.

CLOVERLEAF TRAP

By constructing cages at the unguarded ends of the trap leads, the effectiveness of the cloverleaf trap was significantly increased. End cages, such as illustrated in Fig. 4, were employed at 6 of 11 trap sites during the summer and fall of 1955. Like the central cage, they were constructed of poultry wire and roofed with netting.

Sixteen per cent of the total catch of 128 grouse in the cloverleaf traps during the summer of 1955 was made in end cages. The 20 birds thus captured were a substantial addition to the number caught in the central cages. Of particular interest was the increased incidence of capture in the end cages during late summer and fall. Although only five birds were trapped during July and August in these additions, 15 captures were made by them in September and October. The difference in success between these periods appears to occur as a result of the broods moving about in less compact groups as they enter the period of brood dispersal. The value of this modification would appear to be especially great in areas of high grouse concentrations.

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GRANULAR VENEREAL DISEASE IN A WHITE-TAILED DEER[1]

C. F. Helmboldt and R. D. McDowell

Department of Animal Diseases and Department of Plant Science, University of Connecticut, Storrs, Connecticut

Granular venereal disease (GVD) of cattle (infectious or nodular vaginitis) is a condition affecting the mucosa of the vagina and vulva or the prepuce and penis (Williams, 1939:329–338). It is common in heifers and exists in practically every dairy herd (Roberts, 1956:321–323). Lesions are small reddish nodules or papules up to 2 mm. in diameter. These nodules are compact round-cell foci surrounded by a diffuse round-cell infiltration; they are situated in the derma (Thoms, 1906). Among domestic animals, the disease is found in cattle, goats, sheep, and swine (Williams, *op. cit.*). This article reports the disease in a feral white-tailed deer, *Odocoileus virginianus* ssp.

The specimen was a 135-lb. female secured in New London County, Connecticut, on November 19, 1955. The animal was considered to be 20 months old, according to the Severinghaus (1949) technique. The reproductive tract was removed in the field and included the ovaries, fallopian tubes, uterus, cervix, and a portion of the vagina. Representative tissues were fixed in 10 per cent Formalin, embedded in paraffin, and stained by hematoxylin-eosin.

Gross examination of the reproductive tract revealed a nongravid uterus. Both ovaries contained varied-sized corpora lutea and follicles. Histologic examination of the ovaries confirmed the gross observations and revealed that the corpora lutea were recent, while the follicles were developing, so that some were actually Graafian follicles. Of passing interest was a primary follicle, the ovum of which contained a well-developed nucleus and a degenerating nucleus or polar body. The pathognomonic lesions were found in the mucosa of the proximal vagina. These lesions consisted of many compact foci of lymphocytes, within which vascular spaces were seen (Figs. 1 and 2). The lesions were in the lamina propria. At this level, the epithelium was two cells in thickness and tended toward cuboidal. These lymphocytic alterations ceased abruptly at the cervix.

The etiology of GVD in cattle is not known. Although a virus is believed responsible (Götze, 1949:271–272), successful isolation and reproduction of the disease in this species has not been reported. At any rate the characteristic lesions appear from 2 to 4 weeks after apparent contact (Crawley, *et al.*, 1950) and then subside in about one month (Roberts, *op. cit.*), although individual animals may have lesions for several months. If one is allowed the liberty of assuming that the condition in the white-tailed doe is similar to that in the cow, then it appears that this specimen was infected about one month previously and probably by coitus.

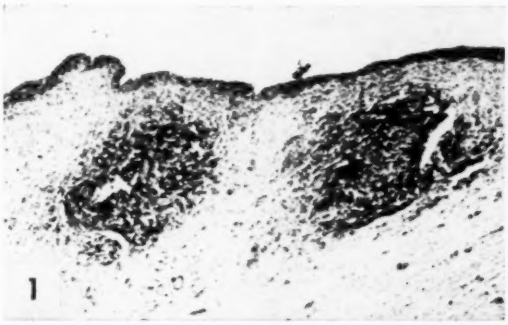

FIG. 1. A section of the mucosa of the proximal vagina. There are two lymphocytic foci in the lamina propria. H & E. × 40.

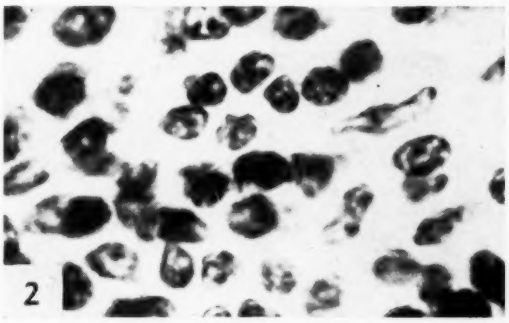

FIG. 2. An enlargement of Fig. 1 showing the lymphocytic cell type which constitutes the pathognomonic lesion. H. & E. × 1215.

SUMMARY

Granular veneral disease (infectious or nodular vaginitis) was seen in a wild white-tailed deer. The histologic appearance resembled that described in the domestic cow.

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AN EPIZOOTIC AMONG EIDER DUCKS INVOLVING AN ACANTHOCEPHALID WORM

Gordon M. Clark, David O'Meara, and James W. Van Weelden

Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Laurel, Maryland; Department of Animal Pathology, University of Maine, Orono; and the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Plymouth, Massachusetts

During the months of September and October 1956, numerous eider ducks (*Somateria mollisima dresseri*) were found dead near Matinicus Island on the Maine coast. In Massachusetts, dead and dying ducks were reported by state game officials in the Chatham to Nantasket area during February 1957. An investigation by state game officials in response to a complaint by a Chatham resident disclosed 12 dead and about 200 weakened eiders in the vicinity of Chatham on March 2. "Large numbers" of dead ducks were also reported on the beaches of Nantucket Island. Coast Guard personnel aboard the Chatham Light Ship reported dead ducks afloat seven miles off shore. Chatham residents were of

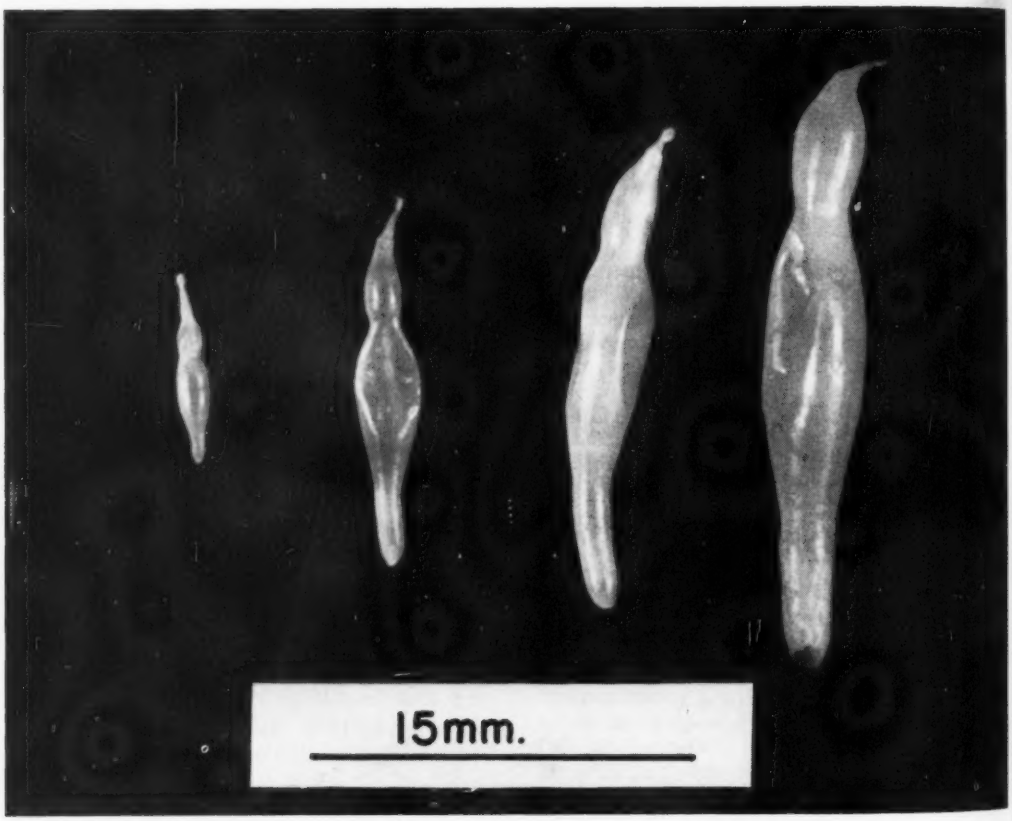

FIG. 1. Whole, expanded specimens of *Polymorphus botulus*.

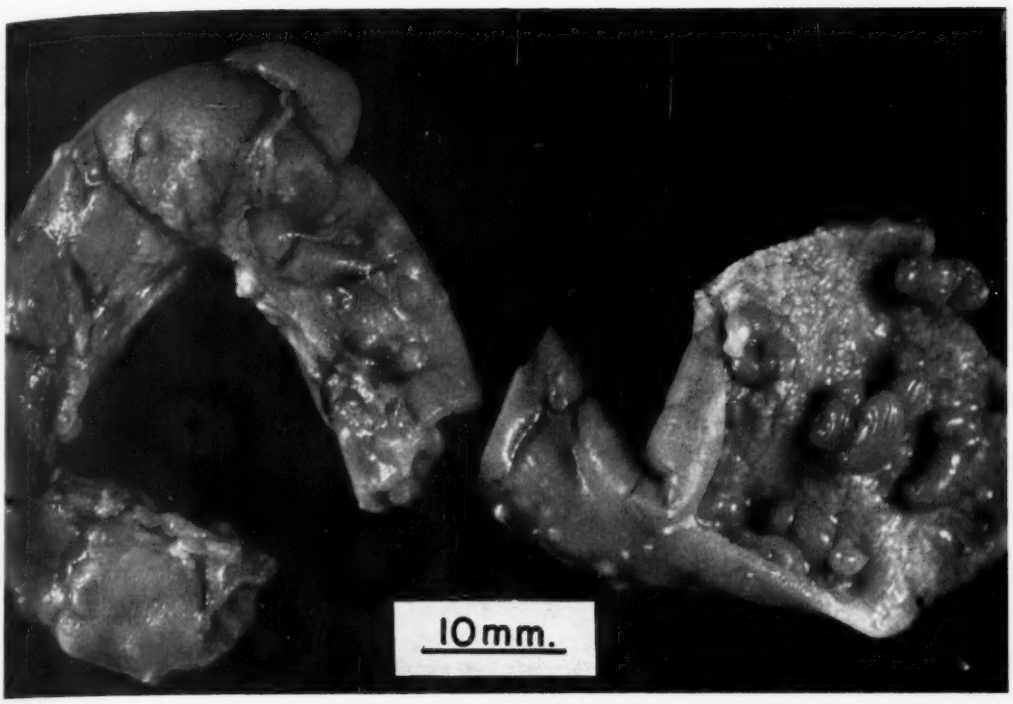

FIG. 2. Intestine of an eider duck infected with *P. botulus*.

the opinion that such losses were not unusual at this time of year. They believed that the trouble was caused by oil pollution from the tanker *Pendleton*, which foundered some five years ago with a quantity of crude oil aboard.

On March 4, 1957, dead and dying eider ducks were noted in the Plymouth–Duxbury area. A number of these birds, together with several from the Chatham area, were sent to the Waltham (Massachusetts) Poultry Diagnostic Laboratory, which reported that the ducks were free of known bacterial pathogens but did have heavy infections of an acanthocephalid worm. On their recommendation, six ducks from Monomoy Refuge, Massachusetts, were sent to the Henshaw Disease Laboratory at the Patuxent Research Refuge for further study.

All ducks were found to be heavily infected by *Polymorphus botulus* (Van Cleave, 1916) (Fig. 1), an acanthocephalid worm of moderate size and a bright orange color. In the heavier infections, as much as 7 inches of the wall of the lower small intestine were covered with parasites (Fig. 2). Although these birds had been dead for a considerable period of time and had been frozen and thawed, it is notable that there was considerable tissue reaction at the point of attachment of the worms. Many had penetrated the intestinal wall and protruded into the abdomen. If such penetration occurs before death, the possibility of peritonitis is indicated. These ducks harbored, respectively, 154, 62, 49, 86, 38, and 235 worms. Three eiders taken in Maine contained 610, 206, and 196 worms.

In addition, four of the eiders from Monomoy Refuge contained intestinal cestodes. Intestinal trematodes were observed in one bird and were judged to occur in sufficient numbers as to cause damage. The gizzards of all six ducks were infected with a nematode of the genus *Amidostomum*. Three kidney flukes and a nasal mite (*Rhinonyssus rhinolethrum*) were recovered from one bird. The feathers of these birds were tinged with crude oil in a varying degree. While this deposit did not appear heavy enough to impair seriously the swimming ability of the birds, the oil could conceivably have had toxic or other deleterious effects.

The findings indicate that *P. botulus* may be a major contributing factor to epizootics among eider ducks. *P. botulus* is holarctic in distribution, having recently been reported from *Somateria m. mollisima* of the Eurasian arctic in addition to *S. m. dresseri* and *S. m. borealis* of North America (Van Cleave and Rausch, 1951). The life cycle of *P. botulus* is not known, but from our knowledge of related forms, we would expect the intermediate host to be one, or a series, of marine Crustacea.

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GOSLINGS DESCEND FROM AERIAL NEST

John J. Craighead and Dwight S. Stockstad

U.S. Fish and Wildlife Service, Missoula, Montana; and Montana State Fish and Game Department, Missoula, Montana

Records of the Canada goose (*Branta canadensis*) nesting in trees and on cliffs are not uncommon (Bradshaw, 1930; Craighead and Craighead, 1949; Hansen and Oliver, 1951; Yocom, 1952; and Geis, 1956). Yocom (*op. cit.*) has indicated that artificial nesting platforms can be used successfully as a management tool to increase nesting of Canada geese. His data show that geese will utilize artificial platforms, but they do not support his contention that this technique increased the number of nesting geese or their productivity.

In 1954, the senior author, with the help of students from Montana State University, erected 81 artificial platforms in Flathead Lake and along the Flathead River, Montana. In 1953, prior to erecting the platforms, the nesting goose population had been accurately measured (Geis, *op. cit.*). We are not yet ready to present the results of this experiment, but we believe a detailed description of how goslings get down from aerial nests and the loss sustained should prove valuable to others working on this problem.

From 1953 through 1957, 1,099 Canada goose nests in the Flathead Valley of Montana have been kept under close observation. Seventy-seven, or 7 per cent, of these nests have been located in trees and on cliffs. These nest sites were from 6 to over 200 feet above the ground and most of them were not directly over water. They included abandoned nests of osprey (*Pandion haliaetus*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaëtos*), and great blue heron (*Ardea herodias*), as well as artificially constructed platforms.

There has been considerable speculation as to how goslings manage to get down from these aerial nests. Yocom (*op. cit.*) cites conflicting observations of adult geese flying to water with a gosling held in the bill and of adults pushing the young out of the nest. Later notes by Yocom (1956) cite observations by a rancher, Steve Krusoff, who saw goslings drop from tree nests to the ground when both adults called. No details of the descent are given.

At Ninepipe Waterfowl Refuge in western Montana on the morning of May 10, 1957, the authors made detailed observations on a brood of goslings leaving an artificial nesting platform. The platform was in a cottonwood tree and situated about 15 feet above the water. Our data indicated that the goose had been incubating between 28 and 30 days. The possibility of observing the goslings leave the nest appeared to be good, so we spent the night nearby, arriving within 175 yards of the nest at 8 A.M.

A 140-foot channel separated us from the island and the nesting geese. A look at the nest through 7×35 binoculars confirmed our suspicion that the eggs had hatched and goslings were still present. Soon after our arrival the goose became restless, stood up and, after about 10 to 12 minutes, flew off the nest to land 25 yards away. She started calling immediately. In less than a minute a gosling walked to the side of the platform and, without hesitation, leaped off and struck the water 15 feet below. A second one repeated the performance 30 to 45 seconds later, and this one was immediately followed by a third. All beat their tiny wings continuously as they descended, and this no doubt helped break the fall. The goose continued to call softly, while swimming in short circles. The gander was ¼ mile away and silent. In less than five minutes two goslings joined the goose, but the third one swam about independently and did not attempt to join its parents.

For 10 or 15 minutes the goose tried to round up the third gosling, but it dove underwater at her approach and appeared to be afraid of its own parent. The gosling continued to dive at 30- to 40-second intervals and would not let the goose herd it. Several times it surfaced within one or two feet of its mother and the other goslings, only to dive immediately and swim 30 or 40 feet underwater before surfacing. The other two goslings maintained body contact with the mother.

After approximately 15 minutes the gander joined the goose and helped her herd the two goslings, one of which was now beginning to dive. Meanwhile the third "errant" gosling wandered farther away, and the adults appeared to lose interest in it. They gradually swam off and were over ¼ mile from the third gosling when we waded out to inspect the nesting box. The nest contained two infertile eggs. Three dried egg membranes indicated that the three goslings were at least 24 hours old and probably older.

There was no indication that the wayward gosling ever joined the brood or that the adults took any further interest in it.

Goslings are hardy, resilient creatures in spite of their delicate appearance. Geis (*op. cit.*) reports two-day-old goslings traveling 2–10 miles to reach brood-rearing areas.

Observations at the 77 aerial nests yielded only one incident where a gosling was killed in making the descent. A sharp stick protruding from the sand impaled the gosling when it struck the ground. Gosling tracks in sand beneath tree nests, comparison of egg numbers with goslings hatched, and

counts of baby geese soon after hatching indicate that most goslings get safely out of these nests—even the very high ones.

While it has been reported that goslings are transported to the ground by the mother, in her bill or on her back, or that they are pushed or dropped out by the parent (Yocom, 1952), these reports are not thoroughly documented. The fact that downy young of tree-nesting ducks such as the wood duck (*Aix sponsa*), common goldeneye (*Bucephala clangula*), and common merganser (*Mergus merganser*) reach the ground by jumping (Kortright, 1942) tend to support our observations and those of Krusoff (Yocom, 1956) for Canada geese. We would like to emphasize that goslings do not simply fall as reported by Krusoff but deliberately jump, and attempt to fly during the descent. At this time they weigh only about 80 or 90 grams in contrast to an average egg weight of 165 grams. They are light and fluffy enough to "parachute" to earth uninjured. This method of getting out of tree nests appears to be natural to the species and well adapted to the situation, since mortality is extremely low. We believe it is the usual procedure for Canada geese. Artificial platforms erected in trees do not, under the conditions studied, present a hazard to the goslings in their ultimate journey to water and brood areas.

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THE FLIGHT DISTANCE IN FREE-RANGING BIG GAME[1]

Margaret Altmann[2]

Jackson Hole Biological Research Station, Moran, Wyoming

Within the framework of long-range behavior studies on big-game animals of Wyoming (Altmann, 1952, 1956a), the problem of reporting reactivity of the game to disturbance by the observer and other intruders was causing difficulties.

It was decided to analyze the existing quantitative measure of flight reactivity in this paper on moose (*Alces alces*) and elk (*Cervus canadensis*). While the study of social and individual behavior in the big, free-ranging mammals is still in the early stages of its development, most of the research done is on a qualitative, observational basis. It was through the efforts of Hediger (1934), a pioneer in this field, that the concept of the "flight distance" was formulated. As a quantitative measurement of reactivity and response, it can be defined as the distance to which a person can approach a wild animal without causing it to flee. A long distance thus would mean a shy animal; a short one a bold one. Closely connected with the flight distance is the distance of aggression, that is, the shortest distance to which one can approach the animal without being attacked. Although these measurements lend themselves to a useful gross classification of animal types under standard conditions, they will not be applicable under variable conditions and in all cases.

In my work (Altmann, 1956b) on patterns of social behavior in big game, it has become apparent that a number of factors can change the flight distance of a species completely. Denniston (1956) and McMillan (1954), working under comparable conditions on moose, found evidence for such variability in the flight reaction toward human intruders.

Factors influencing the flight distance in my wapiti and moose studies were: a seasonally changing threshold of sensitivity due to reproductive and nutritional status; variations due to type of habitat; and variations due to the specific experience of the individual or the group.

Examples of such variations, based on a total of 3,470 observations of moose in Wyoming covering a three-year period, are given in Table 1. As is shown in Table 1, the moose cow with a newborn calf keeps quietly in a restricted space, well selected for cover. She will not move unless an intruder comes close. She will dodge rather than take off because of the poor locomotion of the calf. One week or several weeks later, during July and August, the reaction will be quite different. The cow will defend her calf-territory against other moose and other animal species, but will react to

[1] This research was carried out under a grant from the National Science Foundation.

[2] Present address: Department of Psychology, University of Colorado, Boulder, Colo.

TABLE 1.—FLIGHT DISTANCE OF SHIRAS MOOSE AS MODIFIED BY VARIOUS SITUATIONS

Situation	Month	Flight Distance in Feet (Average of Observation Notes)
Cow with new calf	May, June	30–70
Cow with heeling calf	July	150–200
Bull in velvet	August	100–120
Bulls, prerut	August	60–90
Rutting (bulls and cows)	September, October	10–30
Hunting pressure, both sexes	September, October	200–300
Water feeding	July–October	50–70
Winter group	November–April	20–60
Special adaptations: Reversed reaction (tourist area) or selective reaction (caretaker, fisherman)	Any month	15–35

human intruders with a very long flight distance, the heeling calf close by her side.

The moose bulls in velvet are, on the whole, a wary lot. They do not expose themselves, but stay much in cover and have a long flight distance. The prerut begins in late August. The bulls rub the velvet, get bolder, and their flight distance shortens. As the rutting season gets under way, the moose bulls lose almost all caution; the flight distance dwindles to almost zero.

The females, too, have much less inhibition; they often approach humans or other intruding species.

The beginning of the hunting season cuts into the rutting situation like a catastrophic storm. The flight distance is suddenly stepped up. I have evidence showing that *individual experience* and clues of *general excitement* contribute to this change. The flight distance becomes very long.

In contrast to McMillan (*ibid.*) and de Vos (pers. comm., 1956), I found that water-feeding moose have a definitely shorter flight distance than moose feeding on land.

In the winter grouping, as a loose aggregation, the moose is not flighty at all, so that it is possible to come very close. This behavior is due, in my opinion, to a general lowering of vigor and also to the difficulty of moving fast in deep or crusted snow. Under special experience, however, the moose can give a completely reversed reaction to disturbances. For example, on a tourist-frequented meadow in Yellowstone National Park, I found that moose were highly suspicious of my silent approach under cover. They actually took flight at a long distance, while later, droves of noisy tourists, with car doors slamming, could approach them closely. Similar cases were reported by Denniston (*op. cit.*). When fishing equipment and fishing gestures were simulated by me, moose had a shorter flight distance than without such equipment in wilderness areas frequented by fishermen. This observation was based on 14 cases.

The amount, density, and height of the available cover plants will, of course, influence the "tolerance" of the game to approach. In open country one will find a longer flight distance, and a shorter one in timber or tall shrubs.

The wind direction and strength, as well as fog and weather noises, may screen the approaching person to a great extent, as all experienced hunters know. At dusk and at dawn the tolerance of moose to an intruder appears to be increased. This latter case was also found in elk (wapiti) and mule deer (*Odocoileus hemionus*).

A keener reaction in the moose was caused by olfactory and by auditory cues than by vision alone. Contrasts of background and motion, however, increased visual acuity and reaction considerably. A case of a blind, mature bull moose observed by me provided an example of a modified flight distance. In otherwise good physical condition, and located in rich irrigation fields and meadows, he would tolerate the approach of humans to about 45 feet. At a distance of about 60 feet, he would wheel to visible attention and stand with both ears moving as if locating the intruder. When yielding, he walked with "Spanish gait," that is, lifting the front legs high and stepping at a fast walk away from the intruder to approximately 250 feet when he would resume a listening stand.

If groups of game (elk, moose, or mule deer) are resting, grazing, or browsing in close formation, the individual members of the group will often show a lower flight tendency than solitary animals of the same species. Peripherally located animals of social groups, or solitary animals, are more sensitive in their reaction to an intruder and from their warning signal the whole group or groups nearby will take a cue for flight.

In areas where a human is rarely ever seen, as on the mountain plateaus of the elk summer range at an elevation of 10,000 feet, the elk are not wary. I have at times spent hours on horseback in their

midst without causing flight or disturbance. Once, during a severe thunderstorm, I sought refuge in a side draw of the elk summer range. Amid thunder and lightning, and as hail and icy rain beat down on me, two young bull elk suddenly crowded in right by my side, standing still and waiting for the tempest to pass. Neither one seemed to mind my closeness.

From the cases mentioned above, it is evident that many aspects of animal behavior can be classified and compared under a discriminating application of the concept of "flight distance." But a careful consideration of the situation involved and of the factors at variance has to be included, so that misinterpretation can be avoided.

SUMMARY

The concept of flight distance as a quantitative measure of reactivity of game animals to intruding persons is examined. Variability of flight distance by type of habitat, social grouping, and reproductive and nutritional states are discussed.

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MOVEMENTS OF BEAVER TRANSPLANTED IN NORTH DAKOTA

Edmund A. Hibbard

Museum of Zoology, University of Michigan, Ann Arbor, Michigan

This paper summarizes the known movements of 18 beaver (*Castor canadensis*) that were transplanted in the Missouri River and northeastern North Dakota streams in 1947–53.

Following a period of fur exploitation, beaver populations in North Dakota had reached a low ebb by about 1900. Between 1905 and 1921, occasional open seasons were held, with complete protection afforded from 1921 to 1931. Beginning in 1931 a permit system of harvest was established, which remained in effect until an open season was again declared in 1952. During most of the period of permit harvesting, beaver populations were quite high in the Missouri drainage in southwestern North Dakota, but in the 1930's beaver were still scarce or absent in most of the northern and eastern habitats.

In an attempt to build up populations of beaver in these areas, the North Dakota State Game and Fish Department began to live-trap and transplant beaver into unstocked portions of the state. The program was initiated for restocking purposes, but it later became mainly nuisance-beaver control. Some restocking was carried on as early as 1934, but most of the live-trapping was done between August 1943 and October 1951 by state trapper Alvin Momb. During this period, 466 beaver were trapped and released in 43 of the state's 53 counties. Between May 16, 1947 and October 13, 1948, 96 of these beaver were ear-tagged with No. 3 fish tags and released: 19 in the lakes of the Turtle Mountains, 18 in the Missouri River, 14 in the Sheyenne River, 41 in several tributaries of the Red River in northeastern North Dakota, and 4 in other areas of the state.

In addition to the marked beaver released by Mr. Momb, 59 transplanted beaver were tagged and released between July 17, 1952 and July 1955. These were nuisance animals handled by Warden Edwin Bry and personnel of the fur-bearer project of the North Dakota State Game and Fish Department. From these 155 tagged beaver, there have been 18 recoveries, 10 from the 96 beaver released by Mr. Momb and 8 from the later releases. The low rate of return from the earlier releases was largely because most of the beaver were liberated in areas where they had been requested by landowners and thus received some protection. Since beaver trapping was conducted by permit previous to 1952, the take during this period was also considerably lower than under the present open-season system. Harvests under the permit system rarely exceeded 2,000 animals annually, while up to 7,000 have been taken during open seasons. Table 1 lists all tag recoveries to date.

The stream miles traveled by tagged beaver were calculated from county highway maps. However, the actual stream distances traveled may have been considerably more, since county maps usually do not show all the bends and curves of smaller streams. This can be demonstrated by comparing stream mileages taken from aerial photographs with those taken from county maps. On many small meandering streams, mileage data obtained from the former may be twice that taken from county maps.

TABLE 1.—RELEASE AND RECAPTURE INFORMATION ON TAGGED BEAVER

Tag No.	Date Released	Date Retaken	Time Lapse (Months)	Estimated Release Age	Miles Moved		Stream where Released
					Stream	Air	
47-6	May 18, 1947	Apr. 11, 1952	59	?	7½	6½	Park
47-7	May 18, 1947	Apr. 15, 1953	71	?	10	8	Park
47-8	May 27, 1947	Nov. 1951	54	?	14	10	Missouri
47-13	June 23, 1947	Apr. 14, 1952	58	?	32	16	Park
47-34	Oct. 10, 1947	June 1948	8	?	3	2	Missouri
47-55	Aug. 15, 1948	Dec. 1954	76	?	7	4	Park
47-63	Aug. 16, 1948	Dec. 1953	64	?	17	12½	Park
47-74	Sept. 13, 1948	Oct. 28, 1953	61	?	19	6	Missouri
47-75	Sept. 13, 1948	May 28, 1950	20½	?	16	9	Missouri
47-80	Sept. 26, 1948	Nov. 1953	62	?	12	9	Park
12	Nov. 8, 1953	Jan. 1954	2	yrlg.?	6	6	Missouri
108	Aug. 14, 1952	Nov. 15, 1952	3	kit	3½	3	Pembina
112	Oct. 7, 1952	July 21, 1953	9	adult	¾	¾	Pembina
117	Oct. 10, 1952	May 12, 1953	7	adult	¾	¾	Park
118	Oct. 10, 1952	May 12, 1953	7	adult	¾	¾	Park
121	May 14, 1953	Dec. 1953	7	adult	148	67	Turtle
132	July 11, 1953	Apr. 5, 1955	21	adult	½	½	Pembina
141	Sept. 9, 1953	Apr. 1954	7	?	6	5	Tongue

From Table 1, one can see that the length of time elapsing between release and eventual recapture cannot be correlated with the number of miles moved. Some of the animals retaken after the longest periods had moved only short distances. Fifteen of the animals were steel-trapped during the regular trapping season. The remaining three animals (tagged with numbers 47-6, 117, and 118) were retaken in live-traps set for nuisance beaver and released elsewhere. One of these animals (No. 47-6) had returned to its original capture site in a city park.

Omitting the long movement of No. 121, the average direct air-line distance moved was 5.9 miles and the average stream distance 9.1. Only 3 of the 18 beaver had moved more than 10 air-line miles. The above movements compare to an average movement of 7 stream miles reported for 12 beaver in Maine by Hodgdon and Hunt (1953). Sixteen stream miles was the longest movement these authors reported for transplanted beaver, although one animal released at the point of capture went 29 miles. Denney (1952) found that in Colorado the average distance traveled by 26 transplanted beaver was 10.4 miles; the greatest distance was 30 miles. These were streamside miles measured or estimated by state beaver trappers (Denney, *in litt.*). Beer (1955), working in Minnesota, listed information on the movements of 21 tagged beaver which he released at the point of capture. He had recoveries from distances up to 31 air-line miles and 51 stream miles, although 18 of 23 movements were for less than 8 miles.

Additional information on the long movement exhibited by No. 121 may be of interest. As noted in Table 1, this animal moved 148 stream miles in only 7 months. It was first live-trapped as a nuisance beaver by Edwin Bry in the Forest River at Minto, North Dakota, and released on a branch of the Turtle River 23 miles south of the original capture point. During the same year, this animal was taken by a trapper in Minnesota at a point 5 miles southeast of Borup on the south branch of the Wild Rice River, which lies approximately 19 miles east of the Minnesota–North Dakota border. In order to reach this spot by water, the beaver would have had to navigate three drainages, the Red River and the two tributaries mentioned above. Most of this movement would have been along the Red River between the mouths of the two tributary streams. This portion accounts for 93 river miles or 63 air-line miles.

The rather short movements of most of the animals indicate why transplanting beaver is an effective means of establishing the species in unoccupied habitats. Two unpublished North Dakota Game and Fish reports (Saugstad, 1943; Hibbard, 1952) further show the effect of restocking and allowing only limited trapping. Saugstad found 75 colonies on the Sheyenne River in 1941–42. This was in a stream where, prior to re-introductions of a "few pair" in 1936, beaver had been considered nonexistent. Following another decade of trapping limited to special permits, beaver again became abundant. With the declaration of open seasons beginning in 1952, as many as 800 beaver have been trapped on the Sheyenne River in a single season. This increase is typical of that found on many streams, for at present the species occurs in considerable numbers in all suitable habitats within the state.

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REPRODUCTION IN THE RACCOON IN THE SOUTHEASTERN UNITED STATES

Sturgis McKeever

Department of Zoology, University of California, Davis, California

In New York, raccoons (*Procyon lotor*) mate in late January and the first half of February (Hamilton, 1936). In Michigan, Stuewer (1943) found that most females mated in February and early March, but a few mated as late as May. George and Stitt (1951) found three litters of raccoons near Ann Arbor that they concluded were conceived during mid-January. In West Virginia, Berard (1952) found a lactating female that he concluded gave birth to young not later than August 15. This animal would have mated in early June. On the basis of a single litter from Louisiana, Goldman (1950) stated that in southern localities the season may be more irregular, but there are no definite records of the reproductive season of the raccoon in the southeastern United States.

During 1956, I examined 241 female raccoons, which were collected in southwestern Georgia and northwestern Florida, and 17 were pregnant. The number found to be pregnant and the number examined each month were, respectively: January, 0 of 18; February, 0 of 10; March, 4 of 12; April, 3 of 9; May, 4 of 31; June, 0 of 36; July, 1 of 25; August, 4 of 53; September, 1 of 22; October, 0 of 21; and December, 0 of 4. By comparing the size of the embryos with growth rates reported by Llewellyn (1953), the date of conception was determined for each pregnant female and the breeding season was found to extend from February 10 to August 3. On the basis of these limited data, the percentage of females that mated each month was as follows: February, 17 per cent; March, 41 per cent; May, 12 per cent; June, 12 per cent; July, 12 per cent; and August, 6 per cent. With a gestation period of 63 days, it follows that raccoons in the area studied give birth to young from April to early October, with approximately half of the births occurring in May. Although this is a long breeding period, it is not sufficiently long for a given female to produce two litters.

The number of embryos per female ranged from 2 to 5, with an average of 3.2 and a standard error of 0.18. This is slightly less than the number reported for Michigan where Stuewer (*op. cit.*) found the number of young varied from 3 to 7, with an average of 4.

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BOOK REVIEWS

Hawks, Owls and Wildlife. By John J. Craighead and Frank C. Craighead, Jr. The Stackpole Company, Harrisburg, Pennsylvania, and Wildlife Management Institute, Washington, D.C. 1956. xix+443pp. $7.50.

In *Hawks, Owls and Wildlife* the Craigheads have undertaken an ambitious project—namely, to understand and to explain the meaning of predation. They are concerned primarily with predation by raptors, but point out that "predation by a collective mammalian population appears to be identical with raptor predation, except that mammals lack the mobility needed to concentrate quickly from distant regions into areas of high prey density" (p.328). The objective is clearly stated: "It is essential to know the year-round numbers and composition of the raptor population, as well as its movements, the numbers or densities of prey species, the food habits of the raptors as related to the available prey and a complex of variables affecting the vulnerability of prey species. These data have been gathered and are presented in this work" (p.xviii). The objective has not been met, in my opinion, for two main reasons:

1. The period of study was too short. As the Craigheads rightly insist, predation can best be understood through a study of the total populations of *both* predators and prey. Their total-predation study, however, was limited to two single years (with a gap of five years in between) on one 36-square-mile area in southern Michigan, plus parts of one or two years on a 12-square-mile area near Moose, Wyoming. This work was supplemented by additional raptor studies, without comparable studies of the prey, in parts of several other years on the Michigan study area and a nearby check area of equal size—and, of course, by the Craigheads' almost unequaled background of experience with hawks and owls. Nevertheless, the study of "collective populations"—which the authors list as one of the major contributions of the book—was clearly far too short for the solution of one of the most complex of all ecological problems. This point surely needs no further elaboration.

2. Prey populations were not adequately studied. Meadow mice are an example. "Much emphasis was placed on the study of meadow mouse populations, as it was evident that they formed the chief food of most of the raptors and that their activities and population densities were reflected directly in the activities and population densities of these birds" (p.103). Fall meadow mouse densities on the 36-section Michigan area were determined roughly as follows: In 1941, a "mouse year" (p.356), two four-section subareas were set up, within which meadow mouse habitats were mapped as carrying high, medium, low, or very low densities; density ratings were subjective. Two snap-trap lines were run in high-density habitat and two in medium-density habitat for four nights each. The resulting trap-night indices were: high, 0.386 (232 trap nights); medium, 0.138 (228 trap nights). In 1948, with an estimated population of meadow mice only a quarter as large as in 1941, a single 5-acre high-density plot was trapped out to give both a trap-night index (0.259) and an absolute figure (93 mice per acre). From this the 1941 trap-night indices were converted to mice per acre in the high- and medium-density habitats (139 and 50, respectively); there were no trap-night indices for the low- and very low-density habitats (76 per cent of the subareas), but densities of 2 and 0.5 per acre, respectively, were interpolated. By expanding the percentage of occurrence of each density class as found on the two sample subareas, a total population of about 303,000 meadow mice was calculated for the fall and early winter of 1941–42 for the area as a whole. For the second year of the total population study, 1947-48, the only trap-night figures given are those for the 5-acre plot already described, and the total meadow mouse population was apparently derived thus: "The total acreage of high meadow mouse densities was somewhat less than a square mile. On the remaining area the density was low, with patches of medium density. An estimate placed the meadow mouse population at about 75,000 . . ." (p.111). Summer population figures for prey species are wholly interpolations: "By using the average number of litters or broods per year and the average number of eggs per nest or young per litter, we can calculate a theoretical average productivity of a pair for a breeding season" (p.289). Finally, there were no population estimates for prey species on the Wyoming study area.

By contrast, raptor populations were followed with exceptional thoroughness and skill. This part of the study gives remarkable insight into the organization of a population of hawks and owls on a specific area at all seasons of the year, not from the standpoint of numbers alone but also of such things as daily and seasonal movements; the daily, weekly, seasonal, and home ranges of most of the individuals and the interrelationships among them; food habits and the response of the raptors to differing food conditions; nesting and rearing, with essentially every nest found except in the case of the screech owl. Most of us would be pleased if we could do as well for a single species. The Craigheads have not only made an excellent study of an impressive number of species, they have also learned a great deal about the relationships between species and about the cumulative pressure exerted by the whole community of raptors. These parts of the book, and they make up a great deal of it, are a solid contribution of lasting importance. The interpretative parts, however, because of the serious

flaws in the material on prey populations, need a drastically severe pruning.

There are attractive wash drawings by Jean Craighead George at the head of each chapter, a colored frontispiece by Walter A. Weber, and a well-chosen series of photographs by the authors.—F. N. HAMERSTROM, JR. Wisconsin Conservation Department, Plainfield, Wisconsin.

Of Men and Marshes. By Paul L. Errington. The Macmillan Co., New York. 1957. 150pp. $4.50.

There is probably no other man alive who could have written this book, nor perhaps any man who has ever lived. I can recollect nothing even comparable to it in many years of reading. This is strange in view of the beauty, importance, and interest of those areas where water is becoming land.

Errington has lived so many years as a part of marshes that I should not be surprised if he had developed webbed feet. One could paraphrase Terence and say that nothing marshy is alien to him, but it is, of course, the animal life that most fascinates him and to the study of which he has made the greatest contribution. Since marshes and swamps from the Dakotas to the Volga, and probably much farther east, are one of the environments most persistently and ingeniously destroyed by man, Errington has perhaps come along just in time. Sights he describes from his boyhood will not be seen again in this cycle of American civilization—if ever; and fifty years from now the kind of phenomenon he is currently recording may have vanished, also, from most of Asia, Africa, and South America. Errington's book may be at once history and prophecy.

The book is so concentrated that a description or summary of it is extremely difficult, and so quotable that selection of passages is equally hard. It is concerned with marshes and the long swing of geological time; with marshes and the shorter span of the seasons; with structure of marshes; with marshes and the mind of man; and finally, with some of the generalizations that may be drawn from marshes. By "marsh" is meant the total process. The one adverse criticism I should make of this book is that it could have contained more of the meat of Errington's studies and those of others. In writing for a "popular" audience he has, perhaps, underrated their intellectual appetite.

For one who has been much concerned with the effects of human overpopulation, these discussions of marshes are stimulating. "Nature red in tooth and claw" emerges in these pages as mercifully harsh; the creatures of which Errington writes do not suffer the protracted indignity that accompanies human overcrowding, although these animals also develop their slums. Death on the ditch-banks may be brutal but it is surely far kinder than the years-long cruelty so often perpetrated in the name of Hippocrates and other religious or quasi-religious symbols. Errington sees himself as a sometime predator in the marshland communities. How much more admirable seems this predation, than the predation by ideas, whether they be commercial or political! The wind that blows off the great marshes is a clean wind, and Errington makes one smell it.

He has written this book, he says "to encourage wider participation by the public in the quieter uses of marshes . . ." This the book may do, but in our increasingly mobile age hardly enough to be very significant. The tyranny of the internal combustion engine is not likely to be controlled. In our era of institutionalized "togetherness," quiet is valued less and less. Errington, himself, does not seem optimistic. There is grim, cold comfort, but nonetheless comfort, in his conclusion: "I doubt if man, though he master atomic energy, will be able to circumvent the next glaciation . . . I think there will be glacial marshes on earth after man is gone as a species. . . ." We may hope that at least some of the forms described here will be left to populate them.

Errington has written of these glacial marshes better than anyone before him. I should like to see some foundation send him on a tour of marshes in other parts of the earth to record his impressions before the draglines and bulldozers move in.

Hochbaum's drawings, while to me at times unduly "busy," are enjoyably evocative of moods and places. The binding is sleazy and the price, for a book of this size, seems exorbitant.—WILLIAM VOGT, Planned Parenthood Federation of America, Inc., 501 Madison Ave., New York 22, N.Y.

Arctic Birds of Canada. By L. L. Snyder. University of Toronto Press, Toronto. 1957. 310pp. $4.75.

This is a guidebook to the birds of Arctic Canada. The author has had the usual trouble in defining the limits of the Arctic but decides to define it as the immediate continental coastline from the Alaska–Yukon boundary eastward to Bathurst Inlet, thence overland to Hudson Bay at about Eskimo Point. He includes Ungava Peninsula within his area from Portland Promontory to Cape Chidley. The southern boundary of the Arctic must necessarily be an arbitrary one, but the present boundary seems to me to be more restrictive than the ecology of the region would suggest. However, this is my one point of criticism, because I have found Dr. Snyder's book to be a most worthwhile addition to the literature on North American birds.

The introduction presents some of the problems of Arctic adaptation among birds and introduces the reader to some of the problems and aids in bird identification. There are short lists of the species most likely to be observed on each of the nine main ecological types of the Arctic terrain.

The body of the text treats the 72 species of birds regularly occurring in Arctic Canada. For each

are given the synonyms, both English and Eskimo, the general distribution, a brief treatment of the habitat, an extended description of field characteristics for all ages from egg to adult, including the call notes and behavioural features that are so much help in identification. There are brief remarks on subspecific status. A small range map indicates the area of occurrence of each species. T. M. Shortt has provided a most attractive illustration of each species. In these he has most ably captured not only the details of his subject but the bleakness and majesty of its environment.

An appendix lists 95 species of Subarctic birds that have been recorded occasionally in the Arctic.

The University of Toronto Press has taken a good manuscript and excellent illustrations and produced an attractive book that does it credit.

I recommend this book to the increasing number of young biologists who find the Arctic attracting them into the research fields of the North. They will find in it much food for thought or stimulus to nostalgia, because this is more than just another guide to a regional avifauna.—IAN MCT. COWAN, University of British Columbia, Vancouver, B.C.

North American Head Hunting. By Grancel Fitz. Oxford University Press, New York. 1957. 188 pp., 4 photos. $4.75.

In *North American Head Hunting* by Grancel Fitz, the reader has an opportunity to visualize wilderness experiences with big game in the tradition of early sportsmenship, at a time when the hunter had high standards of behavior and when his zeal for the game he sought was mingled with his enthusiasm for traveling in the wilderness environment of the game. It is refreshing to read about Mr. Fitz's grizzly hunt and his hunt for the Stone sheep in northern British Columbia, his encounter with the mountain lion, the big elk in Wyoming, the mountain goat in high country, and with the others which we classify as big game. These are wilderness experiences. The account of his physical training in preparation for one of his expeditions should serve as good advice in this period of recklessness in embarking on all kinds of adventures.

All sportsmen should give heed to Mr. Fitz's ethical viewpoint in seeking out a wounded grizzly. As he says, the grizzly was wounded "through no fault of his own," and Mr. Fitz felt an obligation to finish the job with merciful dispatch.

This hunter points out that there is danger in shooting at a bear at long distance, thus perhaps only wounding it, with consequent complications. This is very true, and careless long-range firing, whether it be at waterfowl or at big game, is deplorable. However, with regard to the grizzly in particular, I have seen this animal shot through the heart, then run for some distance before falling. There is, then, a serious danger to the hunter in shooting a grizzly at *very close* range.

In his preface Mr. Fitz says something that we could wish all outdoor writers would heed. He expresses his theory "that the facts should never be distorted by even the slightest taint of the sensational and fictional embroidery with which some writers on hunting have dramatized their work." He also abhors the other extreme of understatement. Mr. Fitz here points out a serious consideration in outdoor writing. Presenting the essential truth of an experience with literary skill is a challenge to the ability of the writer.

In appraising such a book, there is an obligation to elaborate somewhat on a few aspects of our attitude toward wildlife and the out-of-doors. Although only hinted at by Mr. Fitz in a few instances, there are certain viewpoints that are important for us. To begin with, the title brings to mind a variety of human enthusiasms. Many sportsmen get a strong, sincere pleasure in procuring big sets of antlers. For some time I served with the Boone and Crockett Club in a western district to measure trophies in the annual contest, and the interest of many hunters in their trophies was obvious. In college some of us were on the track team and, although we could come nowhere near a world record in a race, we were thrilled by the achievement of a five-minute mile. Some like to climb high mountains, and some of us like to know that we have been able to walk 30 or 40 miles in a day. There are many who like to collect antiques, or postage stamps, or a life-list of birds observed.

We sometimes tend to smile at, or criticize, the other fellow's hobby. But so long as we do not interfere with each other, we would do well to judge tolerantly these natural impulses. Today, in the outdoor scheme of things, there have arisen some serious problems in toleration. As more people are becoming interested in it, we realize that the outdoor environment with its fauna and flora belongs to all of us. The binocular has as much right to wildlife as the rifle. The reference to "vermin" is not compatible with the modern view of things, in which each person would like to have the right to like and cherish any of the wild animals that live among us. To many of us, the sight of a wolf or its track on a sand bar is a welcome experience. To such people this animal is by no means merely a predator and nothing more. Furthermore, in this matter, we cannot classify people as shooters and nonshooters. Many who carry a gun or fishing tackle are also staunch defenders of the wolf, coyote, eagle, and many others that some refer to as "vermin."

A few years ago some hunters from California helped me collect antelope for a mounted group in the National Museum. One of them had shot an elk in Wyoming, not far from the place where Mr. Fitz got his. He told me he would never hunt elk again—it was too tame. Henceforth he would use a camera.

Mr. Fitz refers briefly to the harbor seal feeding on salmon. Those few words suggest an issue with

which groups of Alaskan sportsmen are valiantly struggling. As their spokesmen have pointed out, the seal does not subsist entirely on salmon, and along the Alaska Peninsula and in the Aleutians I have seen them feeding on other "rough fish." And who would not enjoy seeing the rookery of sea lions on the beach of Bogoslof Island? The great Alaska brown bear itself eats some salmon, and consequently is looked upon as "vermin" by some commercial interests.

Fortunately, today we are all beginning to cooperate. Many sportsmen are trying to remedy the lowering of standards in sportsmanship. When a guide and his hunter in Alaska threw a smoke bomb into a grizzly den to get it out, and both men were killed, it was a sportsman's organization that vigorously and publicly spoke out in protest against that kind of hunting.

In recent years the direct use of the airplane in hunting has caused protests among Alaskan sportsmen. The widespread use of the jeep and auto in the West, the "weasel" in Alaska after caribou, and the growing use of the airplane to kill game, serve to convert hunting into mere killing. There is much sentiment in Alaska as well as in the rest of the country against the use of the airplane to kill polar bears out on the Arctic ice. Airplane hunting is a subtle encroachment on the human impulse to hunt, an impulse that originally had some element of striving and of personal achievement in outdoor environment. There come to mind reservations about the last chapter in this book, called "Polar Bears in a Hurry."

In outdoor literature today there are enthusiastic accounts of airplane hunting. One is impressed by the fact that the hunter, whether he is pilot or passenger, is thrilled by the performance of the plane, engrossed by the exhilarating sense of going through space. The original hunting contest, seeking game by physical effort on more nearly equal terms, is gone. The game animal is the same. But the airplane hunter takes advantage of all the mechanical contrivances of the machine age to get his game as easily as possible.

Some of the influences we have to consider are subtle, but important. For instance, many of us have naturally used the words "crop" and "harvest" with reference to game. And we think of "wildlife" as "game." Some of us engaged in wildlife work get into administrative jobs. Such terms have crept into our administrative language innocently. But the use of certain words has the faculty of shaping our motives. In this case, we drift into the outlook that, because we are so concerned with the hunter's success, our wildlife becomes a "crop" to be harvested like a yield of potatoes. More and more we become dependent on fish hatcheries and game farms, and we even import exotic birds and mammals, with the result that the original true hunting recreation in wilderness environment, as shown in many of the chapters of Mr. Fitz's book, is degenerating into mere target shooting.

Human activities and attitudes are changing. Thoughtful sportsmen realize that, in this age of gadgets big and small and in the cult of taking it easy, it is harder than ever to hang on to the time-honored ethical standards of sportsmanship. And more than ever before, it is becoming more difficult to save some of our wildlife and the wild country, such as is described in some of the chapters of *North American Head Hunting*. It will take a broader view of the picture; it will take *all of us*, with or without guns, to do the job.—OLAUS J. MURIE, Director, The Wilderness Society, Moose, Wyoming.

Biogeography, an Ecological Perspective. By Pierre Dansereau. The Ronald Press Company, New York City. 1957. 394pp., 137 illus., 40 tables. $7.50.

Biogeography consists of an introductory chapter followed by five chapters on history of biota, bioclimatology, synecology, autecology, and man's impact on the landscape. The author has made a special effort to clarify the language of ecology by eliminating jargon and foggy sentences, and by the use of a style that is clear, forceful, and elegant. This book was written to serve as a text in undergraduate courses in ecology, but its scope goes far beyond that of an elementary text. It also is a valuable reference volume for those with years of experience in this field. Although this book is more than an elementary text, what makes it applicable to undergraduate use is its clear style and ease of reading. The wildlife ecologist or the wildlife manager will broaden his professional background considerably by careful reading of or ready reference to this book with its ecological perspective.

The history of biota—Chapter 1—is based on an intercontinental or a world-wide relationship. It embraces the origin and evolution of the major groups of plants and animals, the trans-hemispheric movements, the criteria of distribution, the notion of flora and fauna, the floristic provinces and regions, and the laws of distribution. This chapter, like those that follow, contains a wealth of stimulating information, and it is difficult for the reviewer to do it justice without sacrificing brevity. Dansereau's treatment of endemic and cosmopolitan species and of species that thrive best near their centers of origin are of special interest.

Chapter 2 treats bioclimatology—the impact of climate as a limiting force upon species. The author treats these limiting forces with emphasis upon factors and elements. He suggests that the factors are latitude (also altitude), distribution of continents, relief, barometric pressure, and marine currents; and the elements are temperature, precipitation, and wind. These factors and elements have established patterns responsible for recurrence of meteorological conditions known as regimens—climatic zones or regions with characteristic seasons. Every species, plant or animal, has an optimum climatic region within which it shows greatest de-

velopment or fulfillment of its life cycle. Where a species occurs beyond its optimum climatic niche (its latitudinal or altitudinal limits), sterility becomes manifest, or the period in completing its life cycle is retarded. Students engaged in population dynamics, or those who have a desire to introduce exotics, will find much thought-provoking material in this chapter. Other topics of particular interest under bioclimatology are: indicators of climatic stress, characteristics of climatic zones, plant formation classes, and effects of altitude.

Synecology—the study of all the organisms within an ecosystem—is the topic of Chapter 3. Synecology is the study of plant or biotic communities, including such factors as their structure, their composition, and their dynamics. And the topic for Chapter 4 is autecology—"the study of an organism, at the level of the species or even the individual, in its relations with its environment." The separation of ecology into two categories, as stated, is a tremendous advancement, for the average book on ecology deals chiefly with plants or biota at the community level. The wildlife ecologist should also be concentrating his attention on the ecology of one species at a time (autecology). Our failure to advance wildlife management is due, in most respects, to inadequate information on the ecology of a game species. The same inadequacy is applicable to our wildlife food and cover plants. Do we know the complete ecological life history of even one species of our most important waterfowl food plants? The same dearth of information is obvious in the literature on a game bird or mammal. This lack of sound information is not a calamity, but it is a real challenge to men who enter wildlife as a profession. The field is new. We find many unsolved problems to challenge our ability. And anyone who reads chapters 3 and 4 of *Biogeography* will be fired with enthusiasm, for these chapters contain much material on a new ecological perspective.

Man's impact on the landscape is the concluding chapter of this volume. The reviewer feels that this chapter alone is worth the price of the book. Society would profit greatly if our humanitarians were encouraged to read it. The subject matter of Chapter 5 deals with disclimaxes. Headings of interest in this chapter are: the scale of human interference; travel, migration, war, and naturalization; lumbering; cultivation; burning and grazing; industry; urbanization; and land-use patterns. This chapter is a "must" reading assignment for students in conservation, wildlife, forestry, and all other applied agricultural sciences.

Beginning students with limited ecological background may be critical of the binomial treatment of plant associations, alliances, orders, or classes on pages 185–186, and which are further explained on pages 200–202. Here the author follows the plant sociological proposals of the Zurich–Montpellier School. The name *Acer saccharophorum* was used in this book for sugar maple instead of *A. saccharum*, and, since both names have been used in the literature, it is anyone's guess as to which will survive.

Profile sketches used in many of the figures throughout the book enhance its appearance and usefulness. Terms used throughout the text and in a glossary of 19 pages, following a very informative appendix, are clearly defined; and Dr. Dansereau is the first writer, to my knowledge, who has clearly defined "union"—a term without connotation when encountered in other publications on ecology.

In all probability, the title of this book will not connote its true value to the wildlife ecologist. This is especially true for those who may come upon the title in book lists. But bound between the two covers of this volume is a treasure of information on bioclimatology and ecology, embracing the entire field of the science of environment. And the author of *Biogeography* has raised what could have been a poorly written and illustrated book to one approaching a masterpiece in modern textbook ecology.—WARD M. SHARP, Pennsylvania Cooperative Wildlife Research Unit, The Pennsylvania State University, University Park, Pa.

Vertebrates of the United States. By W. Frank Blair, Albert P. Blair, Pierce Brodkorb, Fred R. Cagle, and George A. Moore. McGraw-Hill Book Company, New York. 1957. ix+819pp., 434 illus. Cloth, $12.00.

As stated by the publishers, this is the first new manual in almost 25 years to cover all vertebrate groups in the United States, as well as marine birds and mammals of adjacent seas; marine fishes and turtles are omitted. A notable feature of the work is ". . . the introductory material [by W. F. Blair] and the technical treatment of higher categories . . ." by the authors of each part.

It is ". . . the only single volume in which there is even a complete list of U.S. vertebrates"; the only one in which keys to all and descriptions of their geographic ranges are provided; the only modern check list of fresh-water fishes; ". . . the only modern treatment of all United States species of amphibians and reptiles in a single book."

On first examination of this book, one thinks immediately of Pratt's *Manual of Vertebrates*, to which the present production is a more than worthy successor. The job faced by its authors was, of course, vastly greater than that by Pratt, for the period between dates of publication, 1923 and 1957, was one of extraordinary taxonomic activity. At the time of Pratt's second edition, more than 60,000 species and subspecies of vertebrates had been described. It would have been interesting if the present authors had presented comparative figures for 1957. Also, a summary indicating the total number of species treated in the book would have been useful.

It is peculiarly appropriate that five eminent zoologists co-operated in the authorship. Even

with this division of the labors involved, one can but marvel at their temerity, tenacity, and conscientious courage in tackling so comprehensive and demanding a project.

There is some probably inevitable lack of uniformity in species description in this book. The accounts of the birds and mammals are more complete than those of the fishes, amphibians, and reptiles.

On page 92 appears one of the very small number of typographical errors noted by the reviewer. Here the late Dr. J. O. Snyder, the eminent Stanford ichthyologist, is inadvertently referred to as L. O. Snyder.

An apparent slip occurs on page 101, where in one line, the genus *Richardsonius* is said to be "possibly congeneric with *Gila* and *Clinostomus*," then, a little later, the genus *Clinostomus* is said to differ sharply from *Gila* and *Richardsonius*.

On pages 116–124 is one of the most remarkable vertebrate keys this reviewer has ever seen, namely an 8-page closely printed "Key to the Species of *Notropis*." The reviewer has counted 95 species included in this key (pp. 124–134). Dr. Moore deserves a Nobel prize!

A. P. Blair's general accounts of the ancestry, etc., of the amphibians (p.214, and following) the natural history of the orders Urodela (p.216), and Anura (p.242), and identification of larval Anurans (p.286), with reprinting of Grace Orton's key, constitute valuable features.

Similarly, Cagle's account of the reptiles (p.275 and following) is enlightening. In view of the importance of the temporal openings in the classification of reptilian subclasses, line-cut comparative diagrams, like those in Young (*The Life of Vertebrates*, 1952, Fig. 224, p.371) would have been helpful.

As might be expected, much information of an ecological bearing is incorporated in this volume. Probably every persistent structural characteristic reflects some relationship with environment, if our insight and information only were sufficient to disclose it.

With reference to the flight of birds, Brodkorb writes (p.362): "The motive power for the wings is largely supplied by the pectoral muscles on the downstroke and by the back muscles in the upstroke." But, according to Young (*ibid.*, p.426), "depression of the wing [in birds] is produced mainly by a single mass of muscle, the huge pectoralis major . . . . It runs from the sternum and furcula to the under side of the humerus. . . . Elevation of the wing is produced by a muscle also attached to the sternum, lying deep to the pectoralis major and often called the pectoralis minor, but more properly supracoracoideus. Its tendon passes through the foramen triosseum, between the furcula, scapula, and coracoid, to be inserted on the upper side of the humerus. It is assisted by latissimus dorsi and deltoid muscles." Thus, according to Young, the last-named muscles, attached to the back, play a minor role to that of the supracoracoideus in elevation of the wing.

Brodkorb's account of the birds appears to be nearly up to the minute, for the cattle egret (*Bulbulcus ibis*), indigenous to Spain, Africa, and tropical Asia, is included (p.387), and is stated to have ". . . lately invaded northern South America and eastern United States from Florida to Massachusetts." Furthermore, referring to the grebes (pp.372–373), the names Podicipitiformes and Podicipitidae are substituted for the former Colymbiformes and Colymbidae. The American Ornithologists' Union *Check-list* (5th ed., 1957, p.4), however, spells the new names Podicipediformes and Podicipedidae.

To the reviewer the use of the possessive in vernaculars, as of Gambel's quail for *Lophortyx gambelii* (p.438), is unfortunate. The quail does not belong to Mr. Gambel any more than Rainier's mountain (for Mount Rainier) belongs to Rear Admiral Rainier! [Brodkorb follows the American Ornithologists' Union Committee.]

At the bottom of page 584 there are references to Tordoff (1954), Nelson (1954), and Stallcup (1954), but no terminal references to the birds are given, so that the reader is left in the dark as to the exact citation. Terminal references bearing on the other vertebrates, however, are included. W. F. Blair omits several important recent references on the Artiodactyla.

A notable feature of W. F. Blair's portion of the book is his pointing out of numerous disjunct populations of various mammals. Seemingly, to the student of speciation these ultimately should offer further evidence of the place of geographical isolation in the production of new species.

Inevitably there are inaccuracies in statements of distribution. Thus, according to the American Ornithologists' Union *Check-list* (*op. cit.*, p.99), the California condor formerly ranged not only from Washington State to Baja California (as stated by Brodkorb, p.414, this book) but also east (prehistorically) to Nevada, New Mexico, and Texas. The *Check-list* is also much more up to date in its delineation of range boundaries that have recently changed in the northeastern United States in response to a changing climate.

W. F. Blair's statement (p.768, this book) that *Odocoileus virginianus* occurred "formerly through all of the United States except possibly the most arid parts of the Southwest," is inexact. There are areas of considerable size in California and the Great Basin in which, so far as known, the white-tail never occurred. While it is true that these deer are "now locally extirpated in many parts of former range," it is also true that they have manifested remarkable ability to persist close to civilization, as in the vicinity of large metropolitan areas, and recently, in a number of instances, have been definitely extending their range, e.g. northward into Canada, and locally in many states into cut-over or second-growth areas, or even into farmed country.

Although asserted by Blair to be restricted to high elevations in the mountains, actually *Ochotona princeps* (p.658) occurs at an altitude of 300 feet in Clark County on the north side of the Columbia River (Dalquest, Univ. Kansas Pub. Mus. Nat. Hist., 2, p.377, 1948). The cony also drops to low levels northerly in Canada and Alaska.

One of the outstanding values of a book like this is its inevitable implication of the need for further work. There is an excellent glossary, and an unusually complete index.

To the mind of the reviewer, the criticisms here advanced are of small moment, compared with the outstanding and impressive merits of the work. He has found the volume indispensable in connection with teaching vertebrate zoology. The authors are to be warmly congratulated on a tremendous job exceptionally well done. The book should find a place on the shelves of all serious vertebrate zoologists.—WALTER P. TAYLOR, Department of Zoology, Southern Illinois University, Carbondale, Illinois.

The Wild Hunters. By Gene Caesar. G. P. Putnam's Sons, New York. 1957. 252pp., 9 drawings. $3.75.

In view of the precarious state of our wildlife today, our hunting literature requires careful scrutiny. In appraising this book, *The Wild Hunters,* there are at least two aspects to be considered—how the incidents in the lives of the wild hunters are described, and the objective of the author in writing of them.

First, the narrative. I agree with the author that some scientists look upon the animals' reactions as being too mechanistic, with nothing in common with the mentality of mankind. On the other hand, there is undoubtedly a difference in degree. Man uses more imagination and reflection, and his reactions to events may be more violent and dramatic than those of other animals.

This is shown in the chapter on "The Fight at Toklat River." The particular wolf den in question was under investigation all summer, and there were several attacks by the wolf owners of the den against grizzlies that wandered by. Actually, such affairs, as they were recorded in the extended investigation at this same wolf den during the summer, were not as bloody and dramatic as the story, written up at second hand, that got into the outdoor literature.

In this way, traditional notions become fixed in the public mind. After all, the life of a carnivore is something more than one of killing. If a writer wanted to present the life of man, he would not properly portray exclusively what he finds at the Chicago stockyards.

In Chapter 4, "The Wild Dog—Fables and Facts," Mr. Caesar does a service in discussing in detail the case of two children reported to have been raised by wolves in India. His evidence that it was not true, as represented, seems unassailable. The story needs to be considered as a whole, but the author refers to the psychologists and experts in child development, who accepted the story at face value. He agrees that they knew how to conduct research, then adds: "But not one of them knew anything about wolves."

Here is another instance of what we "wildlifers" must guard against. The danger is that we become proficient technicians in a narrow field, without awareness of related fields. Never before has there been greater need for co-ordination among government bureaus as well as in human thinking. There are no longer just a few of us in an unlimited environment.

Along this same line is the motive in writing this book. In my opinion, the introduction and the conclusion, "The Laws of Nature," sum up what the author has in mind and what we face today. Perhaps the author would agree with this question: Shall we end up with a barren civilization, made up of cultivated fields, commemorative statues, and museum pieces—with not a shred left of the living reality to which we fell heir when we inherited this lovely new continent?

Mr. Caesar is very specific in many places. One needs to read the whole of Chapter 12, "The Exterminators," to realize what we face in trying to save the great Alaska brown bear and the polar bear, against the desires of a very few individual cattlemen, and the careless way we look upon such a wonderful wildlife resource as the polar bear. In this chapter the author makes a significant, and eminently democratic, statement: "I can foresee the time when the great trophy animals like the brownie, the silver tip and the polar bear are going to have to be rationed out one per hunter per lifetime. And I can see no reason why any man should kill more than one. I can also see no reason why the bear population need ever be reduced to a level where any future hunter is denied his chance."

Is not this a statement reminiscent of the true sportsmanship we have thought of as an ideal?

In his concluding chapter, the author says some other significant things, of which at random I pick only the following:

"The attitudes and practices that have characterized man's relationships with his fellow predators throughout all history are not going to be changed in the next few decades. But if we did wish to pull the wild hunters back from the brink of extinction, the first step would be to stop spending money, to save the millions that go for bounties and airplanes and poison. The next step would be to take a very small portion of this money and invest it in research and wildlife study, to find out what we were doing before we did anything else."

And the last words of the book: "But even modified by civilization, North America is a giant land. There is still room enough here. Free from bounties and poison and airplanes, preyed upon only by sportsmen using sporting methods, these creatures could survive for centuries, interfering in no way

with civilization, keeping alive a form of recreation that is in itself a major industry, providing a badly-needed escape from the mounting pressures of a steel and concrete world."

Perhaps our hope lies in the fact that people are beginning to say things like that.—OLAUS J. MURIE, Director, The Wilderness Society, Moose, Wyoming.

The Bird Watcher's Anthology. By Roger Tory Peterson. Harcourt, Brace and Co., New York. 1957. xv+401pp., illus. $7.50.

To appreciate this anthology, one must pay strict attention to the title, for this is a compilation of written reactions of *bird watchers* about the object or objects of their watching. It does not include many fine works on other aspects of ornithology. The book is divided into seven parts. Although Part I is labeled "The Spark" and Part VII "The Full-fledged Watcher," the intervening parts are arranged in no particular sequence. The grouping adds the same kind of order one finds in a Whitman's sampler and allows one to pick and choose from the assembled pieces, all of which are eventually chosen.

The array of authors includes many of our outstanding field naturalists. It is easy, therefore, to compare favorite writers or favorite writings with others considered of the same mettle. One might disagree with the anthologist's choice or arrangement of the prose which forms this literary mosaic. I, for one, do not. Like a Peterson painting, the composition, shade, and hues of our language have been deftly chosen and the whole on printed page, as on canvas, is pleasing to the eye and mind.

No one author contributes more than eight pages under any one title in this anthology. All the notes of the ornithological harp are plucked. One can walk with Audubon among the hordes of passenger pigeons, re-count the hawks that, on September 16, 1948, Maurice Broun records as darkening the skies over Hawk Mountain, think and grin at the humorous maneuvering in Birdsmanship as related by Bruce Campbell, or sit with Aldo Leopold in the dusk of an April evening when the sunlight fades to 0.05 foot-candle, and listen to the sky dance of the woodcock.

In all there are 85 bird-watching experiences recorded, from Walden Pond to the lush jungles of New Guinea.

There are over 90 black and white drawings, including an appropriate heading for each literary contribution, plus 13 full-page illustrations and a handsome colored frontispiece.

The author's contribution, besides two essays, are the introductions to the various sections of the book and biographical annotations about each contributing author. I found these to be informative and very well written.

This book should not be gulped, even by the most rapid reader. To enjoy it most is to savor each contribution as a special delicacy. In a scientific world bent of late on reducing all and sundry to a function of some law of physics or mathematics, this anthology challenges the wisdom of such a reduction. This collection of writings will, I am sure, stimulate and inspire the young naturalist and help the seasoned field man crystallize his own experiences, which may have been expressed less articulately or not at all.

I found with considerable satisfaction that Dr. Peterson considers the prose of R. M. Lockley as "unequalled by any other naturalist writing in England today"; this is a view I have long held. I was surprised, however, that such bird-watching writers as Niko Tinbergen, Frank Darling, Edmund Selous, William Rowan, and E. M. Nicholson were not included. I hasten to add that each reader will have his own list of omissions and that, after all, everyone cannot be pleased.

For those interested in the best of bird watching, this is it. To say I recommend the book would be redundant.—ROBERT A. MCCABE, Dept. of Forestry and Wildlife Management, University of Wisconsin, Madison 6, Wisconsin.

Proceedings and Papers/Sixth Technical Meeting/ International Union for the Conservation of Nature and Natural Resources/Edinburgh, June 1956. Published by the Society for the Promotion of Nature Reserves in collaboration with the Nature Conservancy. 1957. xxii+265pp. $3.75 postpaid (available from the Nature Conservancy, 19 Belgrave Square, London, S.W. 1).

This well-edited paper-covered volume is largely in the English language; it covers, in a partly abridged form, the papers and discussions at an important international conference. The first theme, "Management of Nature Reserves on the Basis of Modern Scientific Knowledge," involves 26 papers and takes up 97 pages of the book. A second theme, "Biological Consequences Due to the Presence of Myxomatosis," was reported in full in *La Terre et La Vie*, pages 123–291, July–December, 1956, published by the Société Nationale d'Acclimatation de France. (Copies are obtainable from the I.U.C.R. Secretariat, Brussels.) In the present volume, this section of the conference is summarized in 17 pages. A third theme, "The Rehabilitation of Areas Biologically Devastated by Human Disturbance," covers the general problem of spoil from deep and opencast mining, as well as problems of rehabilitation arising from erosion or fundamental alterations of land use. To this subject, 31 papers, a general report, 62 pages, and a helpful bibliography are devoted. The fourth theme of the conference, "Relationship of Ecology to Landscape Planning," involves 27 papers and 81 pages. The editors appear to have done an extremely efficient job in their abridgment of the proceedings, and the reader is informed that unabridged versions of the papers are filed at the headquarters of the Nature Conservancy in London.

There is much in this volume of interest to the practical game manager. Among the more interesting reports is one on "Some Aspects of the Management of Wildfowl Refuges in Britain," given by the Wildfowl Trust (and presumably the work of Peter Scott and Hugh Boyd). Among other things, this paper briefly reviews the effects of short-term flooding of grassland, as well as certain experiments on other types of flooding. Dementiev has an interesting report on the fauna of the USSR and its protection. Much of his (abridged?) paper is devoted to a description of the administrative procedures by which wildlife management is effected in his country. I was particularly impressed, however, with the tremendous scale on which Soviet scientists and wildlife managers are carrying out schemes involving the introduction of exotic animals. Since 1925, approximately 117,000 muskrats are said to have been introduced in 500 localities in the USSR. Among the other species introduced in several regions are the American raccoon and considerable numbers of American bison. Fish stocking has ranged all the way from *Gambusia* to the sturgeon. Other Soviet introductions include the release of exotics, like the axis deer, in several national parks of Russia and Transcaucasia. Since so many big-game species receive complete protection from hunting in the USSR, it is obvious that game managers there face some interesting problems of overpopulation. These appear to be already evident in the vicinity of Moscow, but the threat of an untouchable big-game species to forest reproduction in the country does not seem to be appreciated.

The value of these proceedings to a North American, of course, arises from the summary of European experience that this book contains. The plant species available to land managers in rehabilitating devastated areas differ only slightly from our own, and it is interesting to see the same ecological principles at work. The emphasis on ecological thinking demonstrated by landscape planners from so many parts of the world is particularly impressive.

While a number of papers in this volume are reported only in summary form, and while some duplication of material has been necessary in the discussions that are given in both English and French, North American wildlife managers will find the reading of this volume an enriching experience—J. J. HICKEY, University of Wisconsin, Madison 6, Wisconsin.

The Fishes of Ohio. By Milton B. Trautman. The Ohio State University Press, Columbus. 1957. xvii+683pp., maps I–XI and 1–172, figs. I–II and 1–172, 38 outline drawings, pls. I–VII (21 species in color). $6.50 plus postage.

This comprehensive, well-documented work is the product of over 30 years of field and laboratory research by an enthusiastic, capable naturalist. It is concerned primarily with the identification, distribution, and habitat of the 160 species (total 172 kinds) of fishes known from Ohio—this section alone covering 488 pages. A summary of the state's glacial history and physiography is followed by 17 pages, of particular concern to conservationists, dealing with the changes wrought in Ohio between 1750 and 1950. The author has carefully sifted statements in the early literature to produce a trustworthy picture of how advancing civilization has modified the landscape and its biota, especially the fishes; the effects of increasing turbidity, siltation, and pollution are capably demonstrated. Fifty pages are devoted to conventional, artificial keys for the identification of the families (illustrated by outline drawings) and of the species and subspecies. Full-page distribution maps for each species show, by different symbols, the distributional patterns during the period from 1920 to 1950 and the correlation between distribution and physiography. Small insert maps give the approximate North American range of each fish.

The drawings represent diagrammatic illustrations based on an average of counts and measurements taken (with few exceptions) from 10 to 50 individuals of each species or subspecies. Hence, they are far more representative than figures based on a single specimen. The 21 colored paintings were executed in 1930 by the same artist responsible for many of the plates in Forbes and Richardson's *Fishes of Illinois*. The work has an attractive binding, a generous format, and is well printed, closing with a 29-page index.

Although the keys are essentially for use in identifying Ohio fishes, the book will be helpful to students of the Great Lakes and Ohio River fish faunas and represents a noteworthy addition to North American ichthyology. This reviewer regrets that Dr. Trautman's store of information on life history was not included. Of high quality and amazingly low price, this work is an excellent buy for students, fishermen, and naturalists.—ROBERT RUSH MILLER, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

EDITORIAL NOTE

Reprints of the "Glossary of Wildlife Terms," printed in our July 1957 issue, may be secured without charge by writing to the Executive Secretary of the Wildlife Society.

The JOURNAL is much in need of major articles for its October 1958 issue; manuscripts should reach the Editor by May 15.